AD-A104 983 CRAWFORD MURPHY AND TILLY INC SPRINGFIELD IL F/G 13/13
NATIONAL DAM SAFETY PROGRAM. INNSBROOK ESTATES DAM NUMBER 1 (MO--ETC(U)
APR 81 R CLAIRMONT, R ANDREWS, E LABELLE DACW43-81-C-0010
UNCLASSIFIED NL

1 of 1
AD A
104983

END
DATE
FILMED
10-81
DTIC

LEVEL

1

MISSOURI-KANSAS CITY RIVER BASIN

AD A104983

INNSBROOK ESTATES DAM NO.1
WARREN COUNTY, MISSOURI
MO. 31714

DTIC
SELECTE
SEP 0 2 1981
D

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
Serving the Army
Serving the Nation

St. Louis District

FILE COPY

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
FOR STATE OF MISSOURI

APRIL, 1981

81 10 2 218

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A104	3. RECIPIENT'S CATALOG NUMBER 983
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Innsbrook Estates Dam No. 1 (MO 31714) Warren County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Crawford, Murphy & Tilly, Inc.		8. CONTRACT OR GRANT NUMBER(s) DACW43-81-C-0010
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		12. REPORT DATE April 1981
		13. NUMBER OF PAGES Approximately 50
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) National Dam Safety Program. Innsbrook Estates Dam Number 1 (MO 31714), Missouri - Kansas City River Basin, Warren County, Missouri. Phase I Inspection Report.		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBI

Approved for release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: Innsbrook Estates Dam No. 1 Dam Phase I Inspection Report
Warren County Missouri
Missouri Inventory No. 31714

This report presents the results of field inspection and evaluation of the Innsbrook Estates Dam No. 1 (MO 31714).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — Chief, Engineering Division — 30 JUN 1981 (Date)

APPROVED BY: SIGNED — Colonel, CE, Commanding — 1 JUL 1981 (Date)

Accession For		
NTIS GRA&I	☒	
DTIC TAB	☐	
Unannounced	☐	
Justification		
By		
Distribution/		
Availability Codes		
Dist	Avail and/or Special	
A		

MISSOURI-KANSAS CITY RIVER BASIN

INNSBROOK ESTATES DAM NO. 1
WARREN COUNTY, MISSOURI
MISSOURI INVENTORY NO. MO 31714

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Crawford, Murphy & Tilly, Inc., Springfield, Illinois
A & H Engineering Corporation, Carbondale, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

APRIL, 1981

PREFACE

This report is prepared under guidance contained in Department of the Army, Office of the Chief of Engineers, Recommended Guidelines For Safety Inspection Of Dams, for a Phase I investigation. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigation, testing and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. Additional data or data furnished containing incorrect information could alter the findings of this report.

It is important to note that the condition of the dam depends on numerous and constantly changing internal and external conditions and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

PHASE I INSPECTION REPORT
NATIONAL PROGRAM OF INSPECTION OF NON-FEDERAL DAMS

Name of Dam:	Innsbrook Estates Dam No. 1
State Located:	Missouri
Inventory Number:	31714
County Located:	Warren County
Stream:	Charrette Creek
Date of Inspection:	15 January 1981

BRIEF ASSESSMENT:

Innsbrook Estates Dam No. 1 was inspected by a team of engineers from Crawford, Murphy & Tilly, Inc. of Springfield, Illinois and A & H Engineering Corporation of Carbondale, Illinois. The purpose of this inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers.

Innsbrook Estates Dam No. 1 is an earthfill embankment constructed in 1979 across Charrette Creek. The dam is located in Innsbrook Estates and is owned by the Aspenhoff Corporation, Clayton, Missouri. It is the intent of the owner to provide a recreational lake for the benefit of future land owners around the lake.

Based on the guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately seven miles downstream of the dam. Located within this zone are 2 houses, a mobile home and County Route F immediately below the dam and numerous other structures, homes and roadways further downstream. The dam is in the intermediate size classification due to its height of 56.4 feet and maximum storage capacity of 5376 acre-feet. Under the guidelines classification an intermediate size dam has a height of 40 feet or more but less than 100 feet and/or a maximum storage capacity of 1000 acre-feet or more but less than 50,000 acre-feet.

Our inspection and hydrologic and hydraulic analyses indicate that the spillway capacity of the dam does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The dam

will hold and pass approximately 33 percent of the Probable Maximum Flood (PMF) without overtopping. The Probable Maximum Flood is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of intermediate size with a high downstream hazard potential pass 100 percent of the PMF. The 1 percent probability flood will not overtop the dam. The 1 percent probability (100-year frequency) flood is one that has a 1 percent chance of being equalled or exceeded in any given year.

The overall condition of the dam appeared to be good although several deficiencies were noted. Erosion gullies on the upstream and downstream slopes should be repaired and good vegetal cover established. The seepage at the toe of the dam should be further investigated and monitored on a regular basis. The riprap and berm along the upstream face of the dam should be reshaped to allow for drainage off the embankment and to fill in thin spots in the riprap. Some form of erosion protection should be considered for the spillway in areas where the exposed bedrock is highly weathered. Another deficiency is the lack of records regarding seepage and stability analyses.

It is recommended that the owners take the necessary action in the near future to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Russell Clairmont, P.E.
Crawford, Murphy & Tilly, Inc.

Robert B Andrews

Robert Andrews, P.E.
A & H Engineering Corporation

Edward LaBelle

Edward LaBelle, E.I.T.
Crawford, Murphy & Tilly, Inc.

PHOTOGRAPH 1. OVERVIEW OF INNSBROOK ESTATES DAM NO. 1.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
INNSBROOK ESTATES DAM NO. 1
MISSOURI INVENTORY NO. 31714

TABLE OF CONTENTS

APPENDICES

APPENDIX A: MAPS AND GENERAL DRAWINGS:

APPENDIX B: HYDROLOGIC AND HYDRAULIC ANALYSIS:

APPENDIX C: PHOTOGRAPHS:

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Safety Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspections of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer, directed that a safety inspection be made of Innsbrook Estates Dam No. 1 located in Warren County, Missouri.

B. Purpose of Inspection:

The purpose of this inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, Recommended Guidelines for Safety Inspection of Dams. These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Innsbrook Estates Dam No. 1 is an earthfill structure approximately 56.4 feet high and 480 feet long at the crest. The dam has a 20" drawdown pipe with an 18" gate valve and the spillway is a trapezoidal channel cut into natural ground at the right abutment. In this report right and left orientation are based on looking in the downstream direction.

B. Location:

The dam is located within Innsbrook Estates, a proposed residential development in Warren County, Missouri, on Charrette Creek. The longitude of the dam is 91° 2.4' West and the latitude is 38° 45.4' North. The dam is located in Section 8, Township 46 North, Range 1 West which is within the Wright City, Missouri 7.5 minute quadrangle map. Included in Appendix A are a location map for the dam on Plate 1 and a vicinity map on Plate 2.

C. Size Classification:

Innsbrook Estates No. 1 Dam has an embankment height of approximately 56.4 feet and a maximum storage capacity of approximately 5376 acre-feet. Therefore, the dam is in the intermediate size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers, has classified this dam as a potential high hazard dam. The estimated damage zone extends approximately seven miles downstream of the dam. Located within this zone are two homes and a mobile home directly downstream of the dam and several other homes and buildings further downstream. The affected structures within the damage zone were verified by the inspection team.

E. Ownership:

The dam, lake and surrounding land are owned by the Aspenhoff Corporation, 165 North Meramec Road, Clayton, Missouri 63105, telephone 314-727-7900. Mr. Steve Wobbe was in charge of the Innsbrook Estates development at the time of inspection, telephone 314-441-0933.

F. Purpose of Dam:

The dam was constructed to form a recreational lake for future residents of the proposed Innsbrook Estates.

G. Design and Construction History:

Lewis and Associates Consulting Engineers, Warrenton, Missouri 63383, were contracted by the owner, Aspenhoff Corporation, to design and construct Innsbrook Estates Dam No. 1. Earthwork on the dam was subcontracted to Paul Hunt of Warrenton and the dam was completed in 1979. During the design phase of the project, water boils were noted in the area of the dam alignment. Pressure grouting was used to seal the voids in the weathered limestone. In addition, a 12"-15" pipe was placed in the embankment to carry water away from the foundation in the event that the grouting operation did not seal all boils.

In 1980 excavation was completed for the spillway channel and a roadway bridge was constructed over the channel.

In addition to the above design and construction, a spillway capacity analysis was carried out by Gateway Consultants.

No modifications of the dam are known to have occurred since completion of the original construction.

H. Normal Operating Procedures:

The only operating equipment at Innsbrook Estates Dam is an 18" gate valve used to control drawdown of the lake. This valve has never been used but according to Mr. Steve Wobbe of the Aspenhoff Corporation the valve is operable. Maintenance of the dam and appurtenant structures is presently the responsibility of the Aspenhoff Corporation. No schedule of maintenance has been set up yet due to the fact that the construction of the lake and dam were recently completed.

According to Mr. Steve Wobbe of the Aspenhoff Corporation, the dam has never been overtopped and there has never been any flow in the spillway. The lake level has been controlled by rainfall, runoff, evaporation and seepage of the lake water into the ground. No evidence of overtopping was noticed during the inspection.

1.3 PERTINENT DATA:

A. Drainage Area (Acres): 4803

B. Discharge at Damsite (CFS):

Maximum known flood at dam site	Not known
Drawdown facility capacity at maximum pool	65
Principal spillway capacity at maximum pool	6144
Emergency spillway capacity at maximum pool	Not applicable
Total spillway capacity at maximum pool	6144

C. Elevation (Ft. Above MSL):

Top of dam	687.9
Streambed at downstream toe of dam	631.5
Normal pool	678.0
Spillway crest	678.0
Pool elevation during inspection 1/15/81	669.0
Apparent high water mark	669.0
Maximum tailwater	Unknown

D. Reservoir Lengths (Feet):

At top of dam	7500
At spillway crest	6800
At emergency spillway crest	Not applicable

E. Storage Capacities (Acre-Feet):

At top of dam	5376
At spillway crest	3287
At emergency spillway crest	Not applicable
At pool level during inspection 1/15/81	1967
At elevation of apparent high water mark	1967

F. Reservoir Surface Areas (Acres):

At top of dam	243.5
At spillway crest	180.6
At emergency spillway crest	Not applicable
At pool level during inspection 1/15/81	146.3
At elevation of apparent high water mark	146.3

G. Dam:

Type		Earthfill embankment
Length of crest (feet)		600
Height (feet)		56.4
Top width (feet)		26
Side slopes (Horiz.:Vert.)	Upstream	3.3:1 below berm 2.3:1 above berm
	Downstream (See cross section on Plate 5, Appendix A)	varies from 3:1 to 3.3:1

Zoning	Unknown
Impervious core	Unknown
Cutoff	Core trench to bedrock
Grout curtain	Along centerline of dam

H. Diversion and Regulating Tunnel: None known

I. Spillway:

I.1 Principal Spillway:

Location	Immediately right of right abutment
Type	Trapezoidal channel excavated in natural ground
Crest elevation (feet above MSL)	678.0
Effective length of weir (feet)	Length varies with elevation (also spillway crest is not complete)
Channel U/S of control section	Approx. 40' long,-10% slope
Control section	Approx. 130' long, 2.8% slope
Channel D/S of control section	Approx. 300' long, 1.5% to 2.3% slope
Side slopes	Irregular (varies from vertical to approximately 1.5H:1V)

I.2 Emergency Spillway: None

J. Regulating Outlets: 20" cast iron drawdown pipe with 18" gate valve

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

Information concerning the design of the dam and lake was obtained from Lewis and Associates, Consulting Engineers, Warrenton, Missouri, and Mr. Steve Wobbe of the Aspenhoff Corporation. The project was initially conceived as a recreational lake for a residential development called Innsbrook Estates planned by the Aspenhoff Corporation, Clayton, Missouri.

An engineering report which includes geologic investigations, hydrologic investigations and a preliminary dam and spillway design was prepared in 1978 by Lewis and Associates.

Prior to construction of the spillway, Lewis and Associates prepared a plan sheet (dated February 1980) showing the spillway design which essentially represents the spillway as it was during the inspection. Based on this plan sheet, a spillway capacity analysis was completed by Gateway Consultants, St. Louis, Missouri, to determine the maximum flood which the spillway could pass. A copy of the engineering report and the plan sheet, which show the dam and lake site, spillway cross sections and soil boring profiles, were obtained from Lewis and Associates, engineers for the project.

Preliminary plans of the proposed principal and emergency spillways differ considerably from the construction plan and as-built conditions. The preliminary design included a drop inlet structure with a concrete outlet conduit as the principal spillway and a shallow open channel near the right abutment for an emergency spillway. The construction plan sheet and as-built conditions include only a deep trapezoidal open channel near the right abutment as both the principal and emergency spillway. Elevations of the dam and appurtenant structures also differ considerably from those originally proposed.

According to Mr. Steve Wobbe, the spillway capacity analyses completed by Gateway Consultants determined that the dam and spillway have the capacity to store and pass approximately 27 percent of the Probable Maximum Flood (PMF) without overtopping the dam.

2.2 CONSTRUCTION:

Information concerning the construction of the dam was obtained from Mr. Steve Wobbe of the Aspenhoff Corporation, owner of the project. The dam was constructed in the summer of 1979 and the spillway was completed in 1980. Lewis and Associates who designed the dam also were contracted to construct the dam. Earthwork at the site was subcontracted to Paul Hunt of Warrenton. Construction inspection was performed by Lewis and Associates.

According to Mr. Steve Wobbe, voids in the bedrock were encountered along the centerline of the dam. Prior to placing the fill material pressure grouting was used to seal these voids. In order to prevent piping through the fill material in the event some voids still remained in the bedrock, a pipe (12" or 15" diameter) was installed in the fill near the left downstream abutment. The pipe extends from approximately the center of the dam to the downstream toe of the dam. The outlet end of this pipe was not visible during the inspection trip but flowing water was apparent in the general location of the conduit outlet.

According to the engineering report, the dam was to be constructed with a core trench excavated to sound bedrock. The fill material for the embankment was to be composed of rolled fill consisting of silts and clayey silts found in close proximity to the dam. There was no information made available to determine if the dam was constructed as planned.

Records of materials testing and construction inspection were not available for this report.

2.3 OPERATION:

The only operating facility at the dam is a 20" drain pipe through the dam with an 18" gate valve located near the toe on the downstream slope of the embankment. This system regulates the drawdown of the lake level. According to Mr. Steve Wobbe of the Aspenhoff Corporation, the drawdown device is operational.

2.4 EVALUATION:

A. Availability:

A preliminary engineering report completed in August 1978 is available and includes a geologic investigation, hydrologic investigation and a dam and spillway design. Many of the recommendations included in this report were not used in the construction of the dam.

A plan sheet showing cross sections and the location of the spillway channel similar to the as-built conditions was drawn in February 1980. According to Mr. Steve Wobbe, a spillway capacity analysis of the design shown on the February 1980 plan sheet was made by Gateway Consultants and it was determined that the dam and spillway have the capacity to store and pass approximately 27 percent of the PMF without overtopping the dam. A copy of the spillway analysis was not available for this report.

No seepage or stability analysis, or construction inspection data were available for the dam.

B. Adequacy:

Due to the fact that recommendations included in the preliminary engineering report were not followed, the engineering data in the report must be considered inadequate.

The calculated spillway capacity as determined by Gateway Consultants is in approximate agreement with the hydrologic findings of this report which states that the spillway can safely pass 33 percent of the PMF without overtopping the dam.

The fact that no seepage and stability analyses comparable to the requirements of the Recommended Guidelines for Safety Inspection of Dams were available is a deficiency which should be rectified. The seepage and stability analyses should be performed for appropriate loading conditions and made a matter of record.

C. Validity:

No conclusions can be drawn concerning the validity of the original design analyses due to the discrepancies between the preliminary engineering report and the as-built conditions.

The results of the spillway analysis completed by Gateway Consultants are in close agreement with the hydrologic findings of this dam inspection report.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on 15 January 1981. The inspection team consisted of personnel from Crawford, Murphy & Tilly, Inc. of Springfield, Illinois and from A & H Engineering Corporation, Carbondale, Illinois. The inspection team met with Mr. Steve Wobbe prior to the field inspection, but he did not accompany the inspection team during the on-site inspection. The members were:

Russell Clairmont, P.E. - Crawford, Murphy & Tilly, Inc.
Robert Andrews, P.E. - A & H Engineering Corporation
Edward LaBelle, E.I.T. - Crawford, Murphy & Tilly, Inc.

The field inspection included the determination of dimensions and elevations of the dam and appurtenances necessary to show a plan view, a dam profile, a spillway profile and cross sections, and a pertinent cross section of the dam. For this report all elevations were obtained by using a USGS control elevation point located near the dam. The control point is located on a concrete box culvert crossing Highway F just west of the dam site. The elevation of the control point is 637.0 feet above Mean Sea Level. Upon comparing elevations obtained for the dam and appurtenant works using this control point with those elevations found in the original design report and on the plan sheets, there is no correlation between the three sets of elevations. It is beyond the scope of this report to determine the reason for the discrepancy between the various sets of elevations.

A visual inspection of the dam, spillway, drainage area, and downstream channel was performed and phot·graphs were taken of each of them.

Maps and general drawings of the dam and appurtenances are presented on Plates 1 through 5 in Appendix A and a hydrologic and hydraulic analysis is presented in Appendix B.

B. Regional and Project Geology:

The general subsurface geology of Warren County consists of Precambrian bedrock overlain by Paleozoic formations. The Mesozoic Era is locally absent through most of this area and the Cenozoic Era is represented usually in surface deposits.

The major structural features in Missouri consist of the Ozark uplift with subsequent basins and numerous glacial features including the major river systems (Mississippi and Missouri).

The Paleozoic rock formations encountered in the subsurface of Warren County consist of Cambrian, Ordovician, Silurian, Devonian, and Mississippian aged rock. The structural attitude of these Paleozoic formations is controlled principally by the shape of the Ozark uplift. The apex of this uplift lies in the St. Francois Mountains (south-southeast of Warren County). The rock units dip away from the apex of this uplift to the northwest through the Forrest City basin and to the northeast through the Illinois basin. The Missouri River and other tributaries expose Ordovician, Silurian, Devonian and Mississippian bedrock throughout Warren County.

The probable extent of both the Kansas and Nebraskan glacial period covered all or part of Warren County and paralleled the Missouri River. The Illinoian glacial period stopped short of Warren County but glacial runoff along the Missouri River and its tributaries was significant. Loess deposits are found throughout most of the upland areas. Recent alluvial deposits replace loess deposits in the Missouri River plain. Also alluvial terraces from primarily the Kansasan glacial period are found along all major valleys in the area including the project site.

The soil cover on the upland areas adjacent to the dam site consist of a light brown modified loess (ML-CL) with thicknesses in the range of 4 to 6 feet. The soil cover in the immediate area of the dam and abutments consist of a silty glacial till with thicknesses in the range of 5 to 15 feet. Soil that was exposed in the banks of the downstream channel indicated a layer or layers of sand and/or gravel near the interface of the soil and rock materials.

A fractured and weathered limestone was observed in the discharge channel and along the downstream slopes. This limestone bedrock appears to be Plattin limestone from the Champlainian series. The underlying bedrock is composed predominantly of dolomite and limestone with several significant sandstone units. Unconformities are conspicuous at both the base and top of the Ordovician bedrock system. Solution features (caves and springs) are present in the Canadian formations.

The dam site is located in Seismic Zone 1 as shown on the Seismic Zone Map in the inspection guidelines.

C. Dam:

Innsbrook Estates Dam No. 1 is an earthfill dam with a height of approximately 56.4 feet and a length at the crest of approximately 600 feet. There is a trapezoidal channel cut into natural ground just right of the right abutment which is the spillway. There is no emergency spillway at the dam. The drawdown works consist of a 20" pipe through the dam controlled by an 18" gate valve. The upstream slope of the dam has a 10' wide berm covered with riprap running the entire length of the dam.

Both vertical and horizontal alignments of the crest of the dam appear fairly uniform. The horizontal alignment of the crest is a straight line and the crest has a width of approximately 26 feet. A gravel roadway runs along the length of the crest of the dam. Photograph 2 shows a view along the crest of the dam.

The elevation of the centerline of the crest of the dam varies from 687.9 to 689.0 or approximately 1.1 feet. The low point of the embankment was apparently caused by greater settlement near the area of the greatest height of fill. This area is located towards the left abutment near the site of the original creek bed. A profile of the crest of the dam is shown on Exhibit 3 of Appendix B.

The upstream face of the dam has a slope of 2.3 horizontal to 1 vertical from the crest down to a berm and a slope of 3.3 horizontal to 1 vertical from the berm to the waterline. Below the waterline the slope is estimated to be 3.3 horizontal to 1 vertical although no measurements were made below the water surface. The 10 foot wide berm is covered with riprap material excavated from the spillway channel near the right abutment. The downstream face of the dam has a varying slope of 3.3 horizontal to 1 vertical just below the crest and a slope of 3 horizontal to 1 vertical on the lower half of the embankment. A typical cross section of the dam can be seen on Plate 5 of Appendix A. Photographs 3 and 4 show the upstream and downstream slopes, respectively.

Erosion was noted along both downstream abutments and along the left upstream abutment to depths of 6" - 18" (See Photograph 5). The cause of the erosion appears to be storm water runoff along the dam. Surface erosion caused by storm runoff on the newly constructed embankment was noted on both the upstream and downstream face of dam to a depth of 3" - 6". No surface cracks or unusual movement or cracking at or beyond the toe of the dam was noticed. No evidence was found of animal holes or burrows on the embankment. Riprap cover on the upstream face is thin in spots and built up very high in others. There is evidence of water ponding between the riprap and embankment in several areas. A view showing the upstream embankment and the riprap can be seen in Photograph 3.

Ground cover on the embankment is generally thin in areas along the downstream face of the dam. Tall weeds were noted between the berm and crest of the dam on the upstream slope and around the gate valve enclosure and outlet of the drawdown pipe on the downstream slope.

Seepage was noted near the base of the left downstream abutment in the general area of the original streambed. According to Steve Wobbe the source of the seepage is a 12" or 15" metal pipe installed in the embankment to carry any water from the weathered bedrock away from the center of the embankment. Pressure grouting of the bedrock was carried out prior to embankment construction, but apparently failed to seal all voids in the rock.

Flow from the seepage area, at the time of inspection, is estimated to be 10 to 12 gallons per minute. Photograph 7 shows a view of the seepage area.

A shallow soil sample was obtained from the embankment near the right upstream abutment between the 10 foot wide berm and the crest of the dam. The sample was classified as a light brown clayey silt with traces of rock fragments (ML).

D. Appurtenant Structures:

D.1 Principal Spillway:

The principal spillway is a trapezoidal channel excavated in the natural ground right of the right abutment. The channel alignment is approximately perpendicular to the dam crest and begins approximately 130 feet upstream from the centerline of the dam and ends approximately 300 feet downstream of the centerline. Discharge from the excavated spillway channel would flow parallel to the toe of the dam on natural ground. There is a ridge of ground which separates the spillway channel from the dam. This ridge is part of the original hillside which was not cut away when the channel was made.

A vehicle bridge was recently constructed across the spillway channel in a straight alignment with the dam crest. When completed, this bridge will be used to carry traffic to and from the dam. At the present time vehicles bypass the bridge site and cross the spillway channel along the spillway crest.

A profile of the centerline of the spillway is shown on Exhibit 4 of Appendix B. Cross sections of the spillway channel at the entrance to the channel and at the bridge are shown on Exhibits 5 and 6 of Appendix B.

The crest of the spillway is irregular and is 115 feet long and approximately 20 feet wide. The crest has an elevation of 678.0 feet at the lowest point. At the present time the crest has a 3" - 4" layer of gravel and is used for a roadway. According to Mr. Steve Wobbe, this roadway will be removed upon completion of the bridge and its approach roads. The approach channel to the spillway crest presently is covered with fill material from the spillway excavation on a slope of approximately 10 percent. The discharge channel has been excavated from highly weathered bedrock and has no vegetative cover. Side slopes of the channel are very irregular and are almost vertical. The spillway is shown in Photographs 8 - 11 of Appendix C.

D.2 Emergency Spillway:

There is no emergency spillway associated with this dam.

D.3 Drawdown Facility:

The drawdown facility consists of a 20" diameter cast iron pipe which extends through the embankment and is located approximately 130 feet right of

the left abutment. The exact length of the pipe and the location of the upstream end is not known. The downstream end of the pipe outlets at the toe of the dam. A wooden enclosure covers an 18" gate valve approximately 10 feet from the outlet of the pipe. The downstream end of the drawdown pipe and the valve enclosure can be seen in Photograph 12. The water in the pipe outlet in Photograph 12 is frozen; there was no discharge from the drawdown works at the time of the inspection. According to Mr. Steve Wobbe, the drawdown device has not been used since its installation. The capacity of the drawdown device is 65 cfs at maximum pool based on the orifice formula using an orifice coefficient of 0.64, a head difference of 51.8 ft. and the 18" diameter of the gate valve.

E. Reservoir and Watershed:

The watershed for Innsbrook Estates Dam contains the lake surface area, recreational areas, building sites, heavily forested areas, pastureland and cultivated areas. The surface area of the lake is approximately 3 percent of the total drainage area at elevation 669.0 which was the water level on the day of the inspection and ranging up to 5 percent at the top of the dam elevation of 687.9. The remainder of the watershed consists of approximately 15 percent developed areas, 50 percent forested areas and 30 percent of land used for pasture or agricultural purposes. A view of the lake is shown in Photograph 13. A typical view of the watershed is shown in Photograph 14.

About 60 percent of the watershed has soil belonging to hydrologic Group D as defined by the SCS and includes soils in the Keswick and Calwoods Series. About 30 percent of the watershed has soil belonging to hydrologic Group C and includes soils in the Hatton, Lindley, and Dockery Series. The remainder of the watershed consists of soils in the Cedargap, Goss, Crider, Nodaway, and Auxvasse Series. These groups of soils are present in only small areas and some of them have not been classified into hydrologic groups. Sedimentation of the reservoir is assumed to have been negligible because of the recent construction of the dam. The sedimentation potential appears to be small if good construction practices are used in developing the property adjacent to the reservoir.

F. Downstream Channel:

The channel downstream of the dam is located along the left side of a relatively broad flood plain. The channel banks are overgrown with brush and young trees, but the rest of the flood plain is covered with grass. Approximately 1300 feet downstream of the centerline of the dam, the channel crosses under a bridge along County Route F. Between the dam and the bridge, the channel has a slope of approximately 1.3% and for a half mile beyond the bridge the channel has a slope of approximately 0.6%, based on USGS mapping. The downstream channel and adjacent flood plain can be seen in Photograph 15.

3.2 EVALUATION:

A number of deficiencies exist with the dam and related appurtenances which should be corrected. The lack of seepage and stability analyses including seismic loadings, is a deficiency which should be corrected.

The seepage noted on the toe of the left abutment should be further investigated and monitored on a regular basis. In order to determine the probable source of the flow, the outlet of the 12" or 15" pipe installed in the embankment should be uncovered and left exposed for monitoring of the quantity and quality of water discharged.

Erosion problems exist on both the upstream and downstream faces of the dam, at both abutments on the downstream slope, and on the left abutment on the upstream slope. All erosion gullies should be repaired and a good vegetal cover established.

Due to lack of slope and surface protection of the highly weathered bedrock exposed in the spillway channel, the potential for erosion during storm water discharge is great. Consideration should be given to lining the channel with concrete or other suitable material to prevent such an occurrence.

The capacity of the spillway channel should be increased as discussed in Section 5.

There was no flow from the outlet from the drawdown works at the time of the inspection, but the presence of ice indicated that there may be leakage past the gate valve. The outlet of the pipe should be checked for flow during warm weather and the situation remedied if leakage is found.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

The only operating equipment at Innsbrook Estates Dam No. 1 is a 20" drawdown pipe through the dam with an 18" gate valve on the downstream slope of the dam to lower the lake water level.

The water level in the lake has been controlled up to the time of the inspection by rainfall, runoff, evaporation and seepage of the lake water into the ground. Should the lake level ever reach the spillway crest, there will be outflow from the lake through the spillway channel.

4.2 MAINTENANCE OF DAM:

The maintenance of the dam is presently the responsibility of the Aspenhoff Corporation under the direction of Mr. Steve Wobbe. The dam has been recently constructed and no maintenance program has been set up at this time. Once ground cover has been well established the upstream and downstream slopes should be maintained on a regular basis. The spillway has been recently constructed and no maintenance has been done.

4.3 MAINTENANCE OF OPERATING FACILITIES:

No maintenance has been performed on the drawdown device since it was originally installed. It is anticipated that the gate valve assembly will be operated periodically to assure its continued operability.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

No warning system is known to exist.

4.5 EVALUATION:

A maintenance program for the dam should be implemented. Erosion gullies on the dam and in the spillway should be repaired and reseeded. The embankment should be mowed regularly to promote a good grass cover and to keep weeds and brush from growing extensively. The gate valve on the drawdown device should be operated occasionally. The outlet of the drawdown pipe should be checked periodically for leakage.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

A preliminary engineering design report was done by Lewis and Associates of Warrenton, Missouri, and was submitted during July 1978. The preliminary engineering design included study of hydrologic characteristics of the watershed, hydraulic features of the dam and spillways, and selection of a lake level.

Many of the recommendations made in the design report were not followed in the construction of the dam. A normal pool elevation of 670.0 was chosen which would have provided a lake of 137 acres with a maximum depth of 30 feet. A two spillway system was recommended with the principal spillway designed to handle the 25-year frequency storm (4% probability storm) and the emergency spillway designed to pass the 100-year frequency storm (1% probability storm) with 1 foot of freeboard between the maximum pool level and the top of the dam. It was recommended that a gated outlet apparatus and a drain system be installed at the dam. None of these preliminary recommendations on the lake level and spillway design were used when the dam was constructed.

A plan sheet showing cross sections and the location of the spillway channel similar to the way it was actually built was drawn in February 1980 by Lewis and Associates. This plan sheet also showed a 20" diameter drain pipe which was built.

A study was completed by Gateway Consultants, St. Louis, Missouri, to determine the maximum spillway discharge. It was determined the spillway could discharge the 27 percent PMF without overtopping the dam.

The significant dimensions of the dam and reservoir were measured or surveyed on the date of the inspection or estimated from available topographic mapping. The maps used in the analysis were the 7.5 minute U. S. Geological Survey quadrangle sheets for Wright City, Missouri, for Foristell, Missouri, for Marthasville, Missouri, and for New Melle, Missouri, all of which are dated 1972. Surface soil information was available from mapping in "Soil Survey of Montgomery and Warren Counties, Missouri."

B. Experience Data:

No recorded rainfall, runoff, discharge or reservoir stage data were available foı the lake and watershed. At the time of the inspection the lake had never risen to the spillway crest and there had never been any outflow from the lake.

C. Visual Observations:

Descriptions of the watershed, reservoir and the spillway are given in Section 3. The lake level will be controlled by the uncontrolled spillway channel. The apparent high water mark was the lake level on the day of the inspection at elevation 669.0. The crest of the spillway is 9.9 feet below the top of the dam and the spillway has a capacity of approximately 6144 cfs when the lake level is at the top of the dam.

A description of the downstream channel is given in Paragraph 3.1F. The downstream hazard zone extends approximately eleven miles downstream. Within this zone are 2 houses, a mobile home and County Route F immediately below the dam and numerous other structures, homes and roadways further downstream.

D. Overtopping Potential:

Based on the hydrologic and hydraulic analysis presented in Appendix B, the dam and its spillway have the capacity to store and pass approximately 33 percent of the Probable Maximum Flood (PMF) without being overtopped. The Probable Maximum Flood is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in a region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this dam which is in the intermediate size category with a high downstream hazard potential classification pass 100 percent of the PMF without overtopping. Thus the spillway capacity of this dam is considered seriously inadequate. The dam and spillway will hold and pass a 1 percent probability flood without overtopping the dam.

Data for the 33 percent PMF, the 50 percent PMF, and the 100 percent PMF are presented in the table below:

Percent PMF	Starting Pool Elevation (MSL)	Peak Inflow To Lake (cfs)	Maximum Pool Elevation (MSL)	Maximum Depth Over Dam (feet)	Peak Discharge (cfs)	Overtopping Duration (hour)
33	678.0	18533	687.75	0	6020	0
50	678.0	28080	690.55	2.65	13405	3.4
100	678.0	56160	694.95	7.05	39215	6.5

The starting pool elevations shown were found by assuming the lake level was at the crest of the spillway at elevation 678.0 and then applying an appropriate antecedent storm four days prior to the storm being analyzed.

The antecedent storm applied in each case was one-half the PMF ratio storm being checked. In each case, however, the reservoir level returned to elevation 678.0 after four days. The spillway has a maximum capacity of 6144 cfs with the lake level at the top of the dam.

The dam will be overtopped by flood flows of less magnitude than the Spillway Design Flood. Overtopping of an earthen embankment could cause serious erosion and lead to failure of the structure. Flood discharges resulting from a failure of Innsbrook Estates Dam No. 1 could be expected to produce substantial stage rises in the hazard zone. Overtopping would lead to potential loss of life and potential damage to the three homes and Missouri Route F immediately downstream from the dam.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Section 3 of this inspection report.

B. Design and Construction Data:

There is available an Engineer's Report prepared by Lewis and Associates along with design plans that include general information concerning soil borings. There is no record of a slope stability analysis being performed for the design of the dam embankment which constitutes a deficiency which should be rectified. The dam embankment and spillway were not constructed as shown on the original plans. There were no "as-built" plans available.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

Post-construction changes include a precast concrete bridge over the principal spillway to complete a roadway over the crest of the dam. The downstream end of the spillway was incomplete at the time of the inspection and should be completed to insure that any flow through the spillway in the future would not result in scouring the downstream toe of the dam embankment.

E. Seismic Stability:

This dam is located in Seismic Zone 1, as shown on Plate 3 of Appendix A. In general, it is anticipated that an earthquake of this magnitude would not cause severe structural damage to a well constructed earth dam of this size. However, a slope stability analysis should be performed, as indicated in the inspection guidelines, to determine if static stability conditions are satisfactory and conventional safety margins exist for this earth dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

A. Safety:

Several items were noticed during the field inspection that could adversely affect the safety of the dam. These items are 1) the seepage noted at the toe of the left abutment, 2) erosion gullies on the upstream and downstream faces of the embankment and along the abutments, 3) erosion potential of the highly weathered bedrock in the spillway channel.

Another deficiency noted is the lack of seepage and stability analyses. This deficiency should be corrected and the results made a matter of record.

The dam will be overtopped by flows in excess of approximately 33 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions of this report were based on the performance history as related by others, visual observation of external conditions, and available engineering data. The inspection team considers that this information is sufficient to support the conclusions herein. Seepage and stability analyses comparable to the Recommended Guidelines for Safety Inspection of Dams were not available and this is considered a deficiency.

C. Urgency:

The remedial measures recommended in Paragraph 7.2 for the items concerning the safety of the dam noted in Paragraph 7.1A should be accomplished in the near future. If good maintenance is not provided, the embankment condition could deteriorate and possibly become serious. The deficiencies concerning spillway capacity should be given a high priority.

D. Necessity for Additional Inspection:

Based on the results of the Phase I inspection, additional periodic inspections are recommended.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Recommendations:

1. The hydraulic capability of this dam should be increased to safely hold and/or pass the recommended Spillway Design Flood which is 100 percent of the PMF. This is normally accomplished by one or more of the following alternative measures:

   a. Construction of additional erosion free spillway capacity.

   b. Provision for additional flood storage by:

      i. Increasing the height of the dam.

      ii. Permanently reducing the normal pool elevation.

2. Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.

3. The seepage area at the base of the left abutment should be further studied to determine if all of the flow is from the 12" - 15" metal pipe as reported by Mr. Steve Wobbe. This will entail digging up and exposing the downstream end of the pipe which is apparently near the surface of the toe of slope.

B. Operation and Maintenance Procedures:

1. Erosion gullies on the dam should be repaired and reseeded.

2. The berm and riprap on the upstream face of the dam should be reshaped to allow drainage off the embankment and to fill in several thin riprap areas.

3. Erosion protection should be considered for the spillway channel particularly in the areas of highly weathered rock which could erode during flow through the spillway.

4. The dam should be monitored for further erosion in the future and repaired as necessary.

5. The upstream face of the dam should be monitored for erosion due to wave action.

6. Any animals that begin burrowing in the embankment should be removed and their burrows filled.

7. The dam should be periodically inspected by an experienced engineer and records kept of these inspections and maintenance efforts.

8. The outlet of the drawdown pipe should be monitored for leakage and the situation should be remedied if leakage is found.

PHASE I INSPECTION REPORT

APPENDIX A

MAPS AND GENERAL DRAWINGS

APPENDIX A

MAPS AND GENERAL DRAWINGS

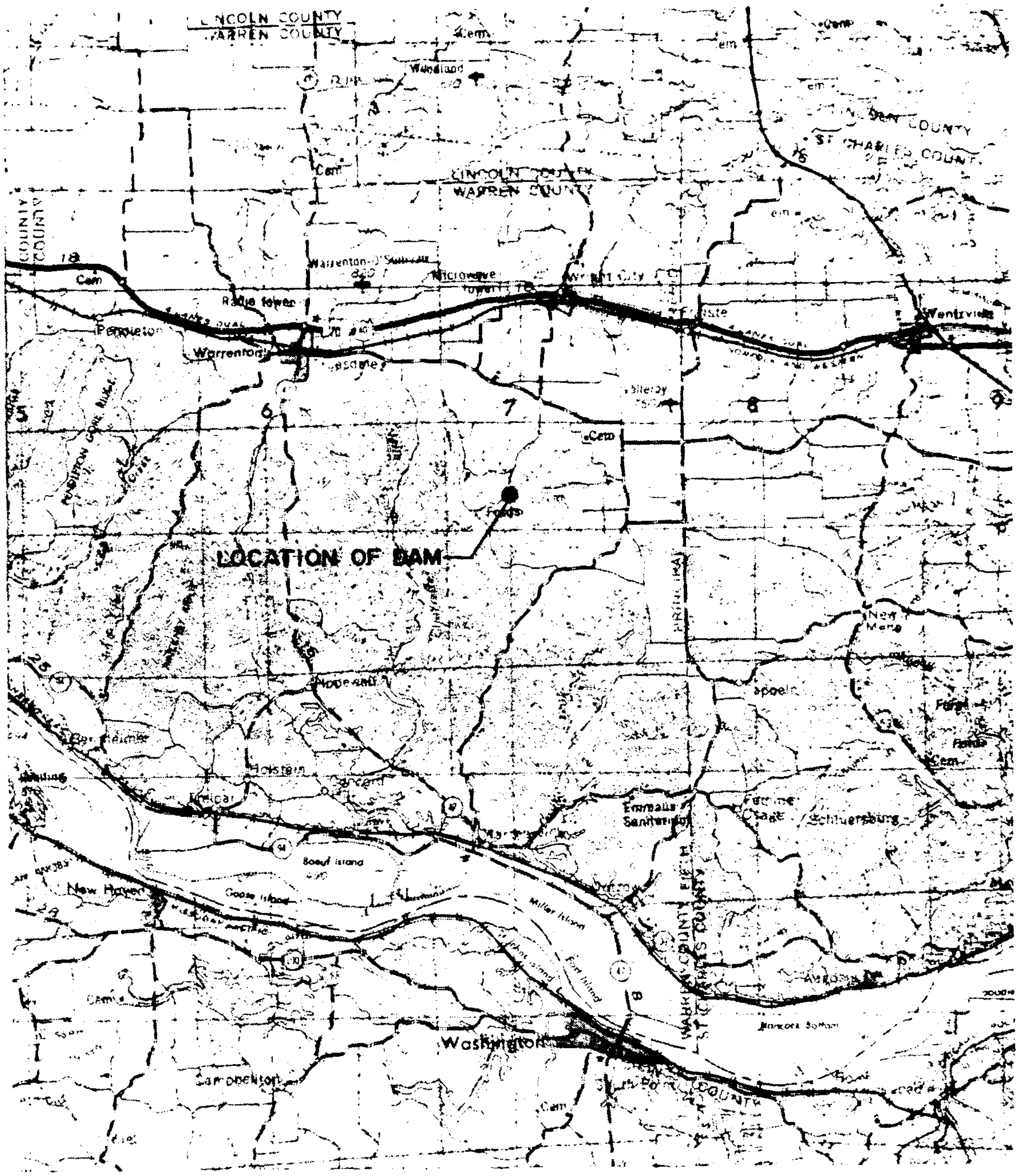
TABLE OF CONTENTS

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM

LOCATION MAP

INNSBROOK ESTATES DAM NO. 1 MO31714

PLATE 1

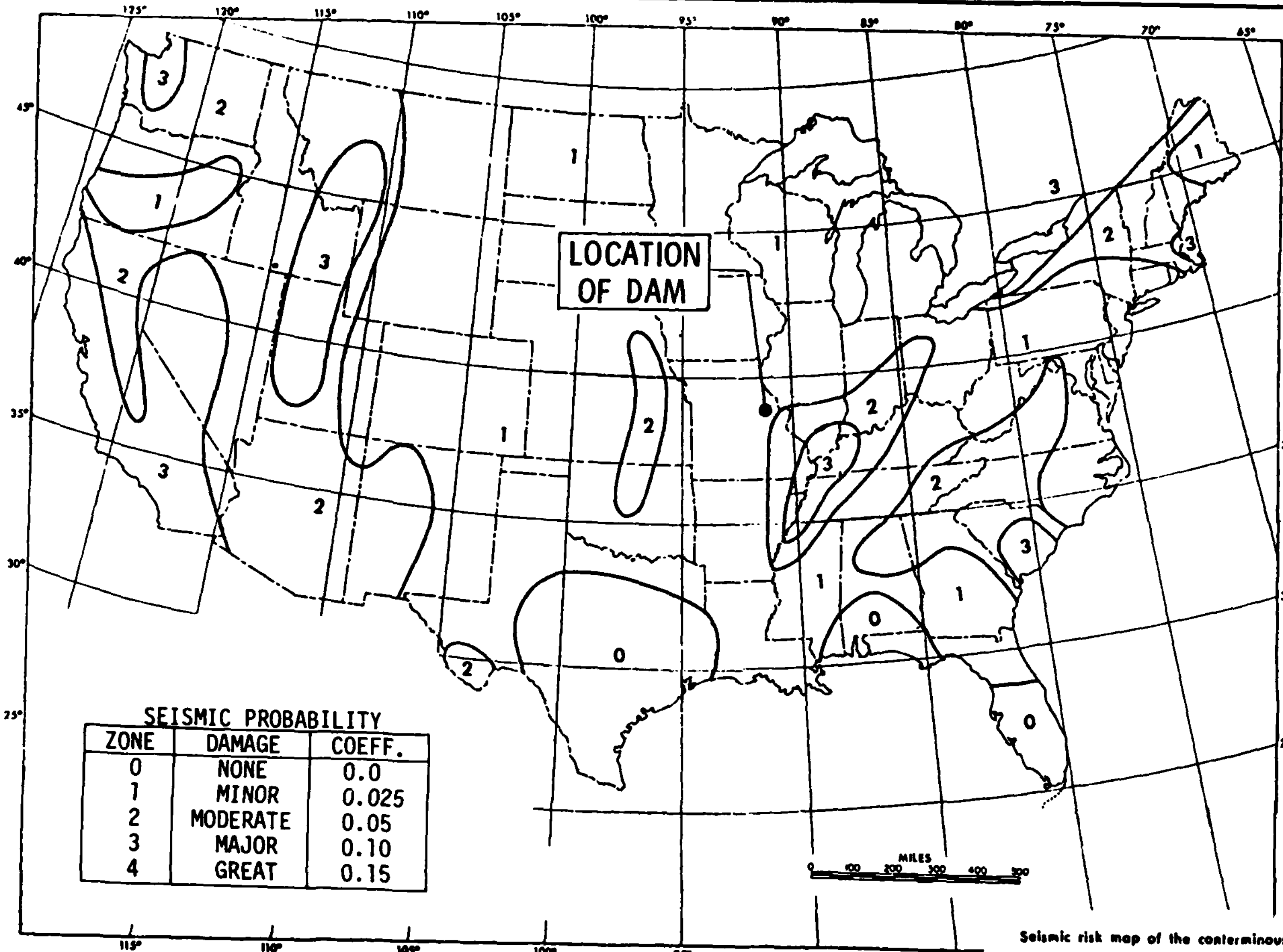


N

SCALE
1:250,000

CM&T	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	VICINITY MAP INNSBROOK EST. DAM NO.1 MO31714

PLATE 2



SEISMIC PROBABILITY

ZONE	DAMAGE	COEFF.
0	NONE	0.0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

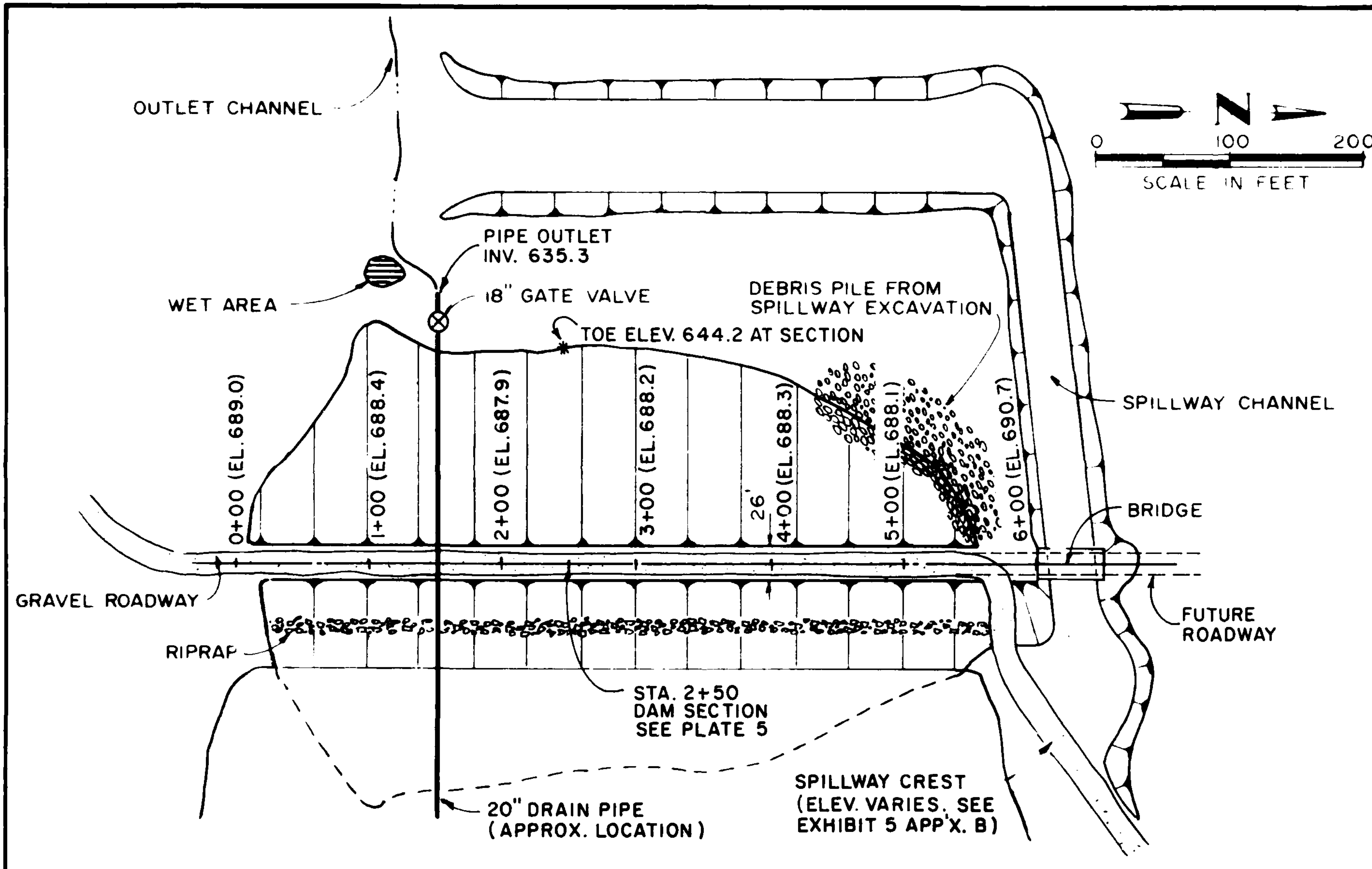
Seismic risk map of the conterminous United States.
Adapted from Algermissen [36]. 288-D-2786.

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers
SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

SEISMIC ZONE MAP OF CONTIGUOUS STATES
INNSBROOK ESTATES DAM NO.1 MO31714

PLATE 3

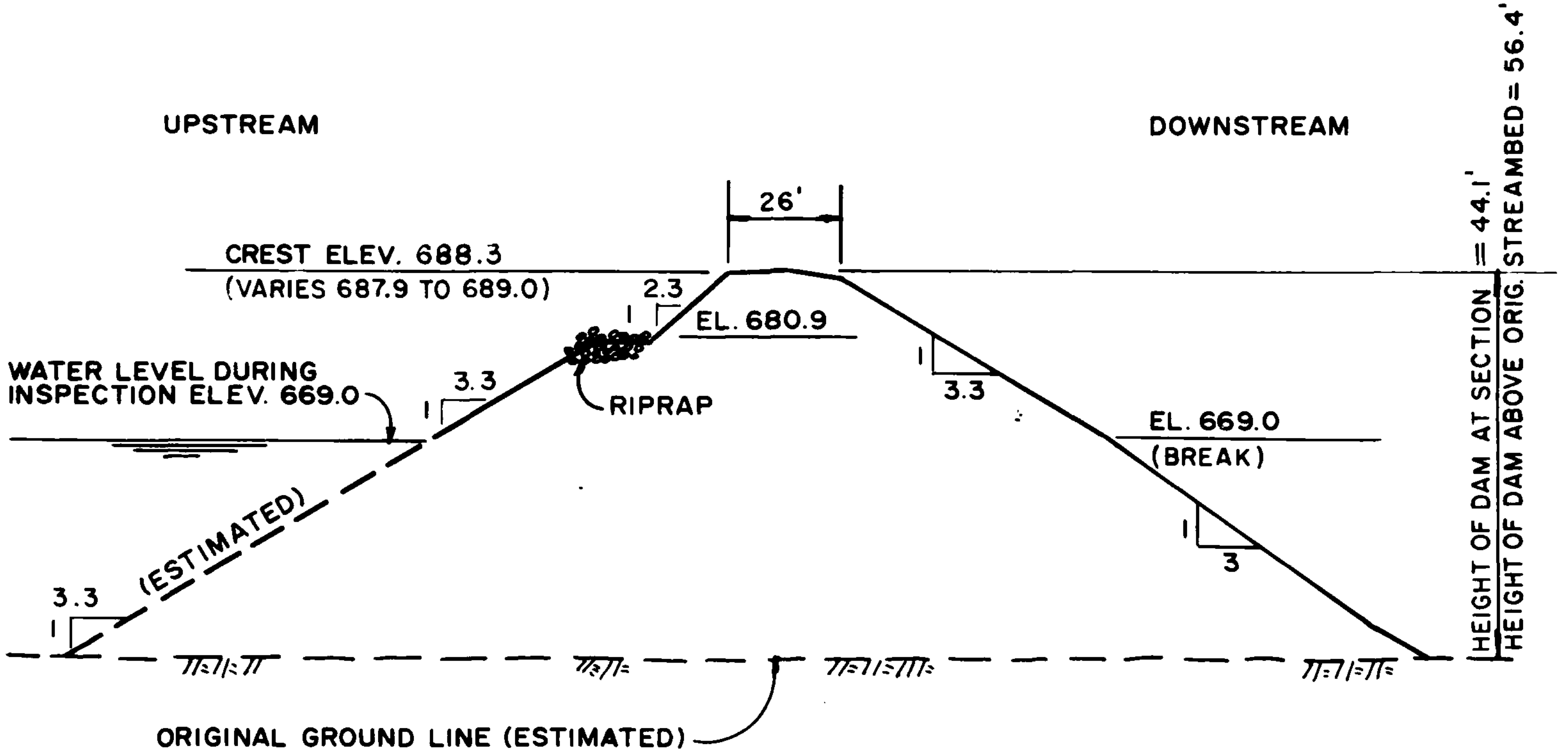


CRAWFORD MURPHY & TILLY, inc Consulting Engineers
SPRINGFIELD IL • LINCOLN IL • AURORA IL

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

PLAN OF DAM AND SPILLWAY
INNSBROOK ESTATES DAM NO.1 MO31714

PLATE 4



CROSS SECTION OF DAM AT STA. 2 + 50

APPROXIMATE SCALE
HORIZ. 1" = 40'
VERT. 1" = 20'

CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	CROSS SECTION OF DAM INNSBROOK ESTATES DAM NO. 1 MO31714

PHASE I INSPECTION REPORT

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

TABLE OF CONTENTS

EXHIBITS

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSIS

A. PURPOSE:

The purpose of this Appendix is to present the methodology used and the results of the hydrologic and hydraulic analysis. The analysis was done according to criteria presented in the Recommended Guidelines for Safety Inspection of Dams and in the St. Louis District Hydrologic/Hydraulic Standards for Phase I Safety Inspection of Non-federal Dams dated 22 August 1980. The purpose of the analysis is to determine the overtopping potential for Innsbrook Estates Dam No. 1.

B. HYDROLOGIC AND HYDRAULIC ANALYSIS:

The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for a reservoir routing. Data for determination of the unit hydrograph was obtained from the U.S. Geological Survey 7.5 minute quadrangle maps for Wright City, Missouri, for Foristell, Missouri, for Marthasville, Missouri, and for New Melle, Missouri, all of which are dated 1972, and from the field inspection.

The drainage area for Innsbrook Estates Dam No. 1 was divided into two subareas for this analysis and a unit hydrograph was determined for each subarea. The unit hydrographs from each subarea were then combined to obtain the unit hydrograph for the complete drainage area. A lake and watershed map showing the drainage area boundary and subarea boundaries is shown on Exhibit 1. There are several small lakes in the drainage area upstream from Innsbrook Estates Dam No. 1. The combined drainage areas of these small lakes is about 10 percent of the total drainage area and the effect of the lakes on the determination of the unit hydrographs was neglected. The parameters used in the development of the unit hydrographs are presented in Table 1.

TABLE 1

UNIT HYDROGRAPH PARAMETERS

	Subarea 1	Subarea 2
Drainage Area (A)	3.85 sq. miles	3.65 sq. miles
Length of Watercourse (L)	1.23 miles	2.41 miles
Difference in Elevation (H)	175 feet	200 feet
Time of Concentration (Tc)	0.45 hours	0.93 hours
Lag Time (Lg)	0.27 hours	0.56 hours
Duration (D)	0.10 hours	0.10 hours
Time to Peak (Tp)	0.32 hours	0.61 hours
Peak Discharge (Qp)	5820 cfs	2900 cfs

Total Drainage Area = 7.50 square miles

Unit Hydrographs from the Computer Output

Time (Minutes)	Subarea 1 Unit Hydrograph Discharge (cfs)	Subarea 2 Unit Hydrograph Discharge (cfs)	Combined Unit Hydrograph Discharge (cfs)
0	0	0	0
6	1193	216	1409
12	4073	646	4719
18	5783	1321	7104
24	5208	2166	7374
30	3521	2722	6243
36	2008	2886	4894
42	1231	2779	4010
48	739	2459	3198
54	440	2037	2477
60	265	1505	1770
66	160	1122	1282
72	96	857	953
78	60	671	731
84	38	516	554
90	18	391	409
96		299	299
102		228	228
108		175	175
114		134	134
120		103	103
126		79	79
132		60	60
138		46	46
144		36	36
150		28	28
156		23	23
162		17	17
168		12	12
174		7	7
180		2	2

Formulas Used:

$$Tc = \left[\frac{11.9\ L^3}{H}\right]^{0.385}$$ From "Design of Small Dams", 1973

$$Lg = 0.6\ Tc$$

$$Tp = \frac{D}{2} + Lg$$

$$Qp = \frac{484\ A \cdot Q}{Tp}$$ Q = Excess Runoff = 1 inch for unit hydrographs

The hypothetical storm that is applied to the unit hydrograph is the Probable Maximum Precipitation (PMP). It is derived and determined from regional charts prepared by the National Weather Service in Hydrometeorological Report No. 33. No reduction factors have been applied to the PMP. A 24-hour storm duration is assumed with total depth distributed over 6-hour periods in accordance with procedures outlined in EM 1110-2-1411 (SPF determination). The maximum 6 hour rainfall period is then distributed to hourly increments by the same criteria. Within-the-hour distribution is based upon NOAA Technical Memorandum NWS HYDRO-35. The non-peak 6 hour rainfall periods are distributed uniformly. All distributed values are arranged in a critical sequence by the SPF. The final inflow hydrograph is produced by deduction of infiltration losses appropriate to the soil, land use, and antecedent moisture conditions. Soil information was obtained from mapping included in "Soil Survey of Montgomery and Warren Counties, Missouri" and land use and slopes were determined from the field inspection and available mapping and are presented in Section 3. Antecedent Moisture Condition III (AMC III) was used for the analysis of the PMP percentage storms.

A 1 percent probability storm was also analyzed. The rainfall amount and distribution for the 1 percent probability storm with a 48 hour duration for a drainage area of 7.5 square miles for the St. Louis, Missouri area was obtained from the St. Louis District, Corps of Engineers and used for the analysis. Antecedent Moisture Condition II (AMC II) was used for the analysis of the 1 percent probability storm. The rainfall applied, the parameters used to determine infiltration losses, and the resulting runoff are presented in Table 2.

TABLE 2

RAINFALL-RUNOFF PARAMETERS

Selected Storm Event	Storm Duration (hours)	Rainfall (inches)	Subarea 1 Runoff (inches)	Subarea 1 Losses (inches)	Subarea 2 Runoff (inches)	Subarea 2 Losses (inches)
PMP	24	32.50	31.75	0.75	31.57	0.93
1% Probability Storm	48	8.26	6.01	2.25	5.65	2.61

Additional Data:

	Subarea 1	Subarea 2
SCS Runoff Curve Number for AMC III used for the PMP ratio storms	94	92
SCS Runoff Curve Number for AMC II used for the 1% probability storm	81	76
Percent of drainage area that is impervious	1%	9%

The reservoir routing is accomplished by using the Modified Puls routing technique in which the flood hydrograph is routed through lake storage. The hydraulic capacity of the spillway and the crest of the dam are used as outlet controls in the routing. Storage in the pool area is defined by an elevation-storage capacity curve. The hydraulic capacity of the spillway and top of the dam are defined by elevation-discharge curves.

The elevation-storage capacity curve was developed by determining the lake surface area at various elevations using available mapping and then inputting this information to the HEC-1 computer program. The computer program then developed an elevation-storage capacity curve using the conic method. An elevation-area-capacity curve is shown on Exhibit 2.

For the overtopping analysis the top of the dam is the lower of the following elevations: (1) The minimum elevation of the embankment as determined by simple field surveys. (2) The lake elevation at which corresponding spillway channel outflow velocities, as determined from simple hydraulic formula, exceed the suggested maximum permissible mean channel velocities. The top of the dam was determined to be 687.9 which is the minimum elevation of the embankment. Outflow velocities in the spillway channel when the lake is at this elevation are at or below the suggested maximum permissible mean channel velocities for rock spillways. Although the spillway channel is not completely rock-lined, as discussed in Section 3.1D, and some erosion will occur, the erosion is not expected to significantly affect the channel cross section or its crest elevation.

The elevation-discharge capacity curve for the top of the dam was developed using the non-level crest option of the HEC-1 computer program. The program assumes critical flow over a broad-crested weir. A profile of the dam crest is given on Exhibit 3.

The hydraulic capacity of the spillway channel was determined using the "HEC-2 Water Surface Profiles" computer program. The HEC-2 program computes water surface profiles in a channel for either subcritical or supercritical flow. Cross sections, slopes, channel roughness and other channel characteristics affecting head loss in the channel were input to the computer. The computer then determined the water surface elevation in the lake for a given discharge. The profile of the spillway flowline and cross sections of the spillway channel as surveyed in the field were used in this determination and they are shown on Exhibits 4, 5 and 6. The elevation vs. spillway capacity obtained from the HEC-2 computer program and input to the HEC-1 computer program is shown in Table 3.

TABLE 3

LAKE ELEVATION VS. SPILLWAY CAPACITY

Values Input To The HEC-1 Computer Program

Lake Elevation (MSL)	Spillway Capacity (cfs)
678.0	0
679.33	250
679.98	500
680.91	1000
682.28	2000
683.40	3000
684.93	4000
686.38	5000
687.72	6000
688.97	7000
691.34	8000

The dam overtopping analysis has been conducted by hydrologic methods for this dam and lake. This analysis determines the percentage of the PMF hydrograph that the reservoir can contain without the dam being effectively overtopped. According to Hydrologic/Hydraulic Standards developed by the Corps of Engineers, St. Louis District, an antecedent storm should be applied to the watershed before analysis of the PMF. The antecedent storm precedes the storm being analyzed by 4 days and the starting elevation at the beginning of the antecedent storm is the mean annual high water mark. Since the lake level has never been to the spillway crest elevation, the high water mark is below the spillway crest. For this analysis the spillway crest elevation of 678.0 was felt to be the appropriate starting elevation at the

beginning of the antecedent storms. The analysis of each of the PMF ratio storms is a storm half the magnitude of the storm being analyzed. During the antecedent storm, the reservoir level would rise and after 4 days, outflow from the spillway would return the lake to the spillway crest elevation of 678.0. This elevation was used as the starting elevation for the analysis of the 33 percent PMF, 50 percent PMF, and 100 percent PMF.

The antecedent storm for the analysis of the 1 percent probability storm is the rainfall in the 24 hours preceding the peak 24-hour period assuming a 48-hour duration. The spillway crest elevation of 678.0 was used as the starting elevation for the analysis of the 48-hour 1 percent probability storm.

The above methodology has been accomplished for this report using the systematized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U. S. Army Corps of Engineers, Davis, California. The numeric parameters estimated for this site and input to the program are listed on Exhibit 7. Definitions of these variables are contained in the "User's Manual" for the computer program.

The inflow and outflow hydrographs, obtained from the computer output, for the 33 percent, 50 percent PMF, and 100 percent PMF storms are shown on Exhibits 8, 9 and 10. The computer printout summary table for the overtopping analysis is presented on Exhibit 11.

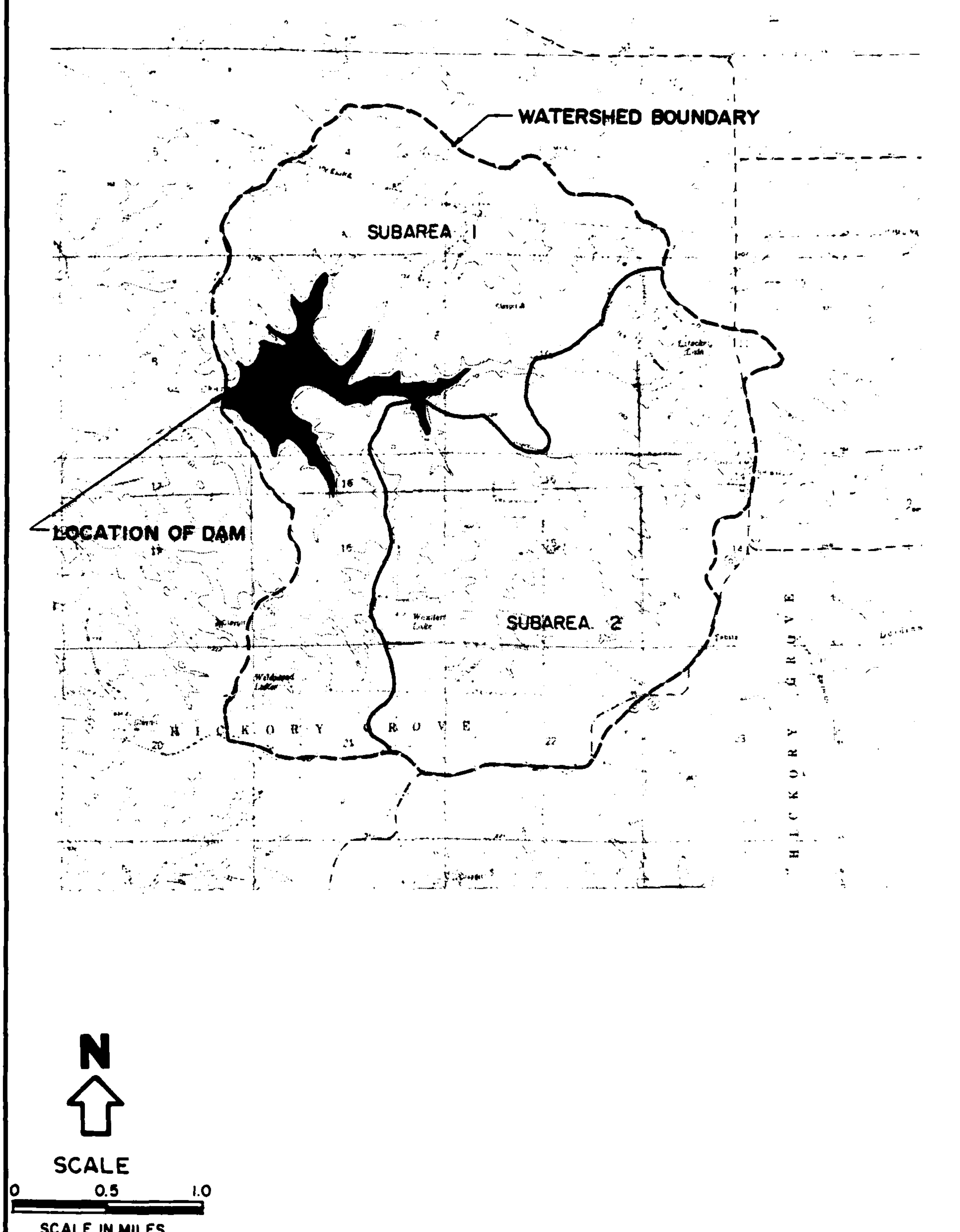
C. <u>REFERENCES</u>:

a. <u>Design of Small Dams</u>, United States Department of the Interior, Bureau of Reclamation, Second Edition, 1973.

b. <u>Flood Hydrograph Package (HEC-1), Users Manual for Dam Safety Investigations,</u> The Hydrologic Engineering Center, U. S. Army Corps of Engineers, Davis, California; September, 1978.

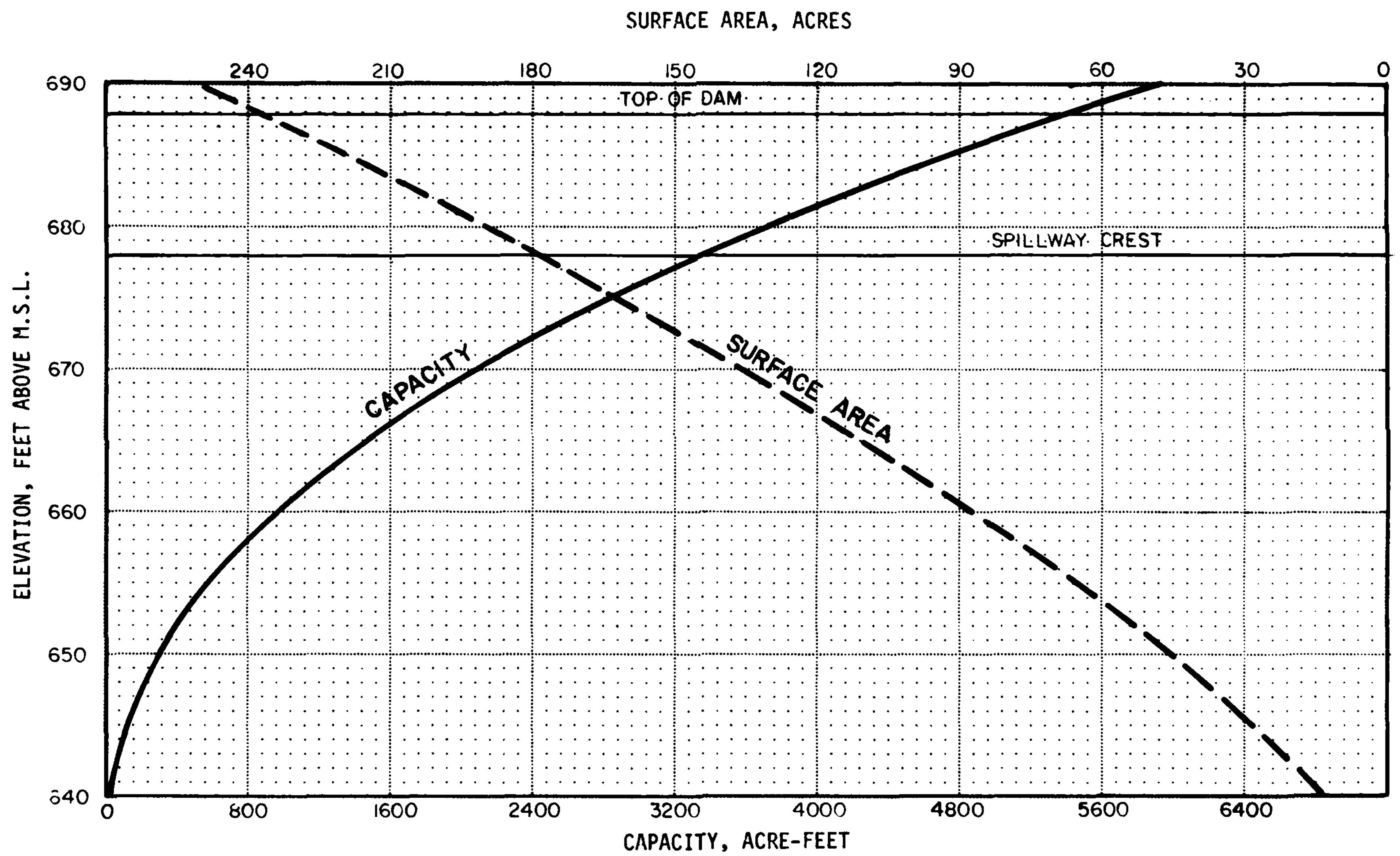
c. <u>HEC-2, Water Surface Profiles, Users Manual with Supplement</u>, The Hydrologic Engineering Center, U. S. Army Corps of Engineers, Davis, California; November, 1976.

d. Riedel, J. T., Appleby, J. F., and Schloemer, R. W., <u>Seasonal Variation of the Probable Maximum Precipcitation East of the 105th Meridian for Areas from 10 to 1000 Square Miles and Durations of 6, 12, 24 and 48 Hours</u>, Hydrometeorological Report No. 33, U. S. Department of Commerce, Weather Bureau, April 1956.



CMT	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	LAKE AND WATERSHED MAP INNSBROOK EST. DAM NO.1 MO31714

EXHIBIT 1

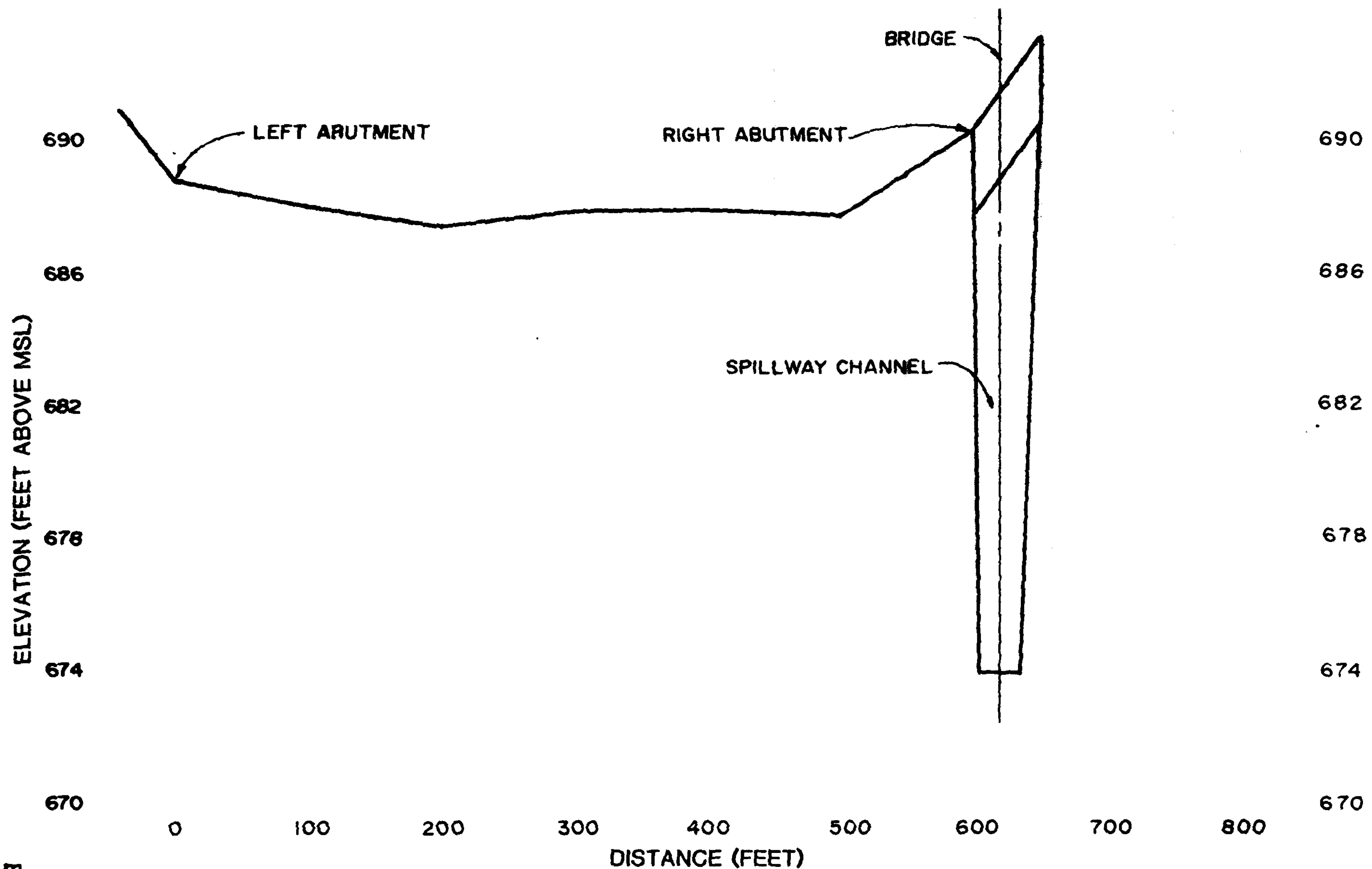


CRAWFORD MURPHY & TILLY, inc. Consulting Engineers
SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

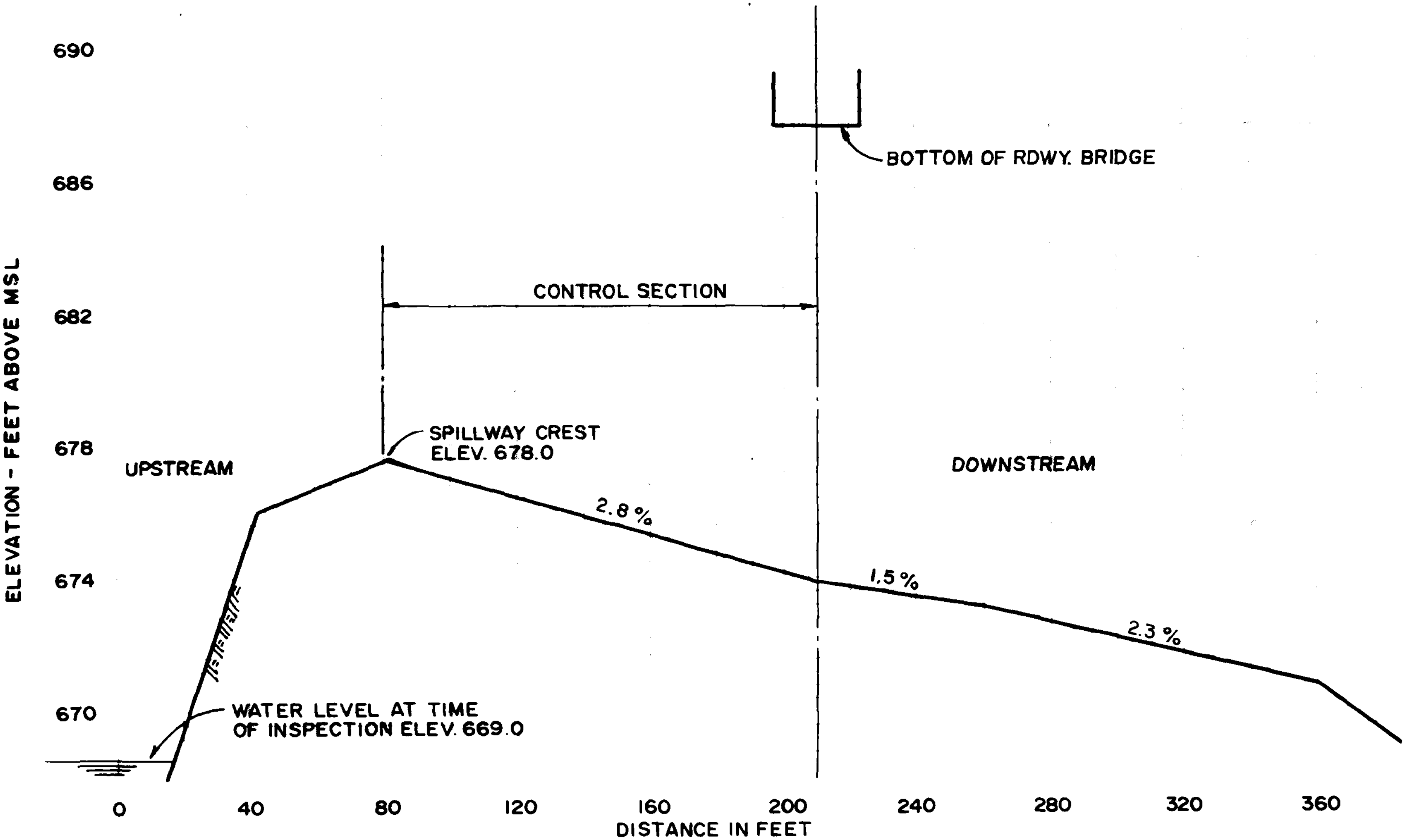
ELEVATION - AREA - CAPACITY RELATION
INNSBROOK ESTATES DAM NO. 1 MO31714

EXHIBIT 2



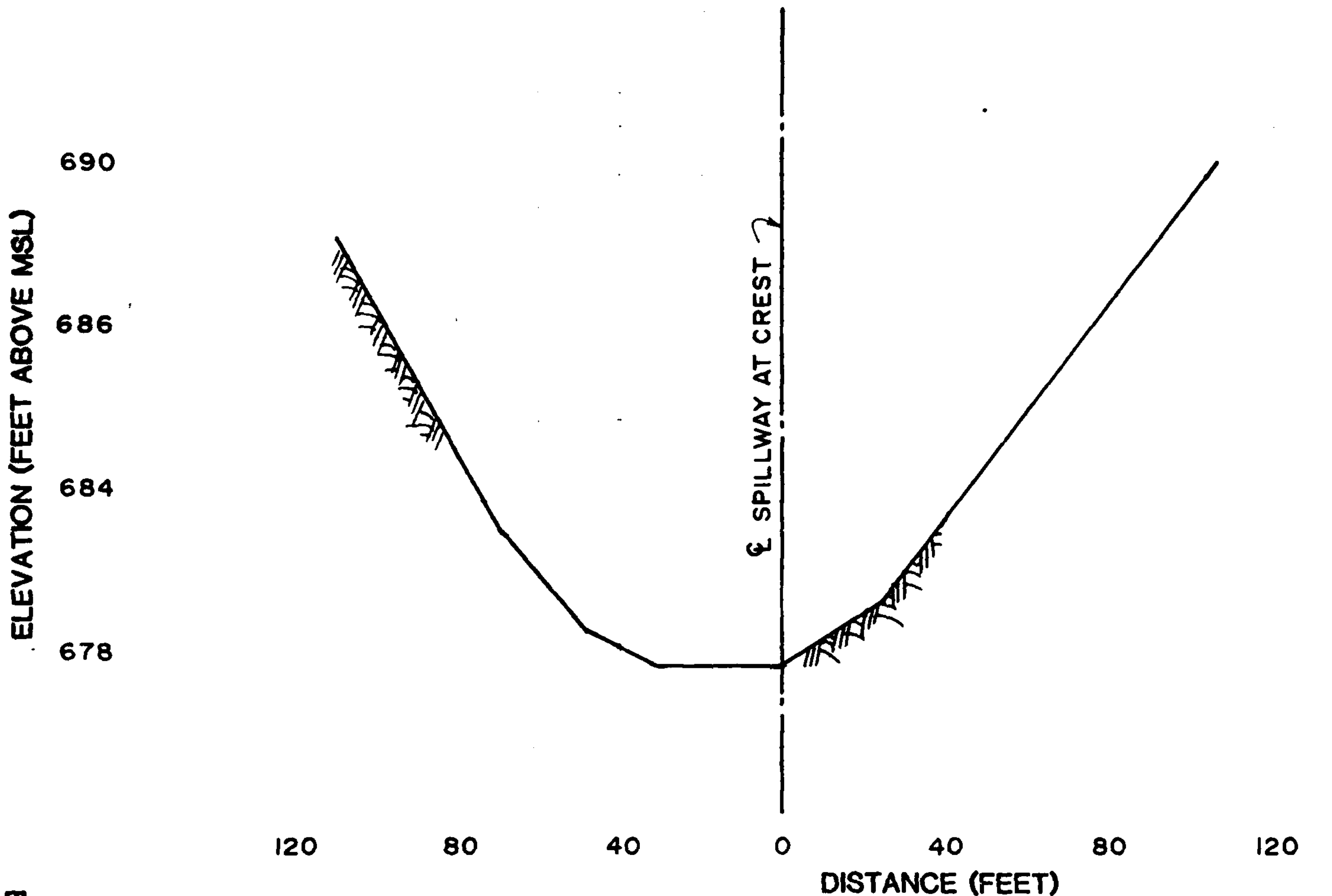
CRAWFORD MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	PROFILE OF DAM CREST INNSBROOK ESTATES DAM NO.1 MO31714

EXHIBIT 3



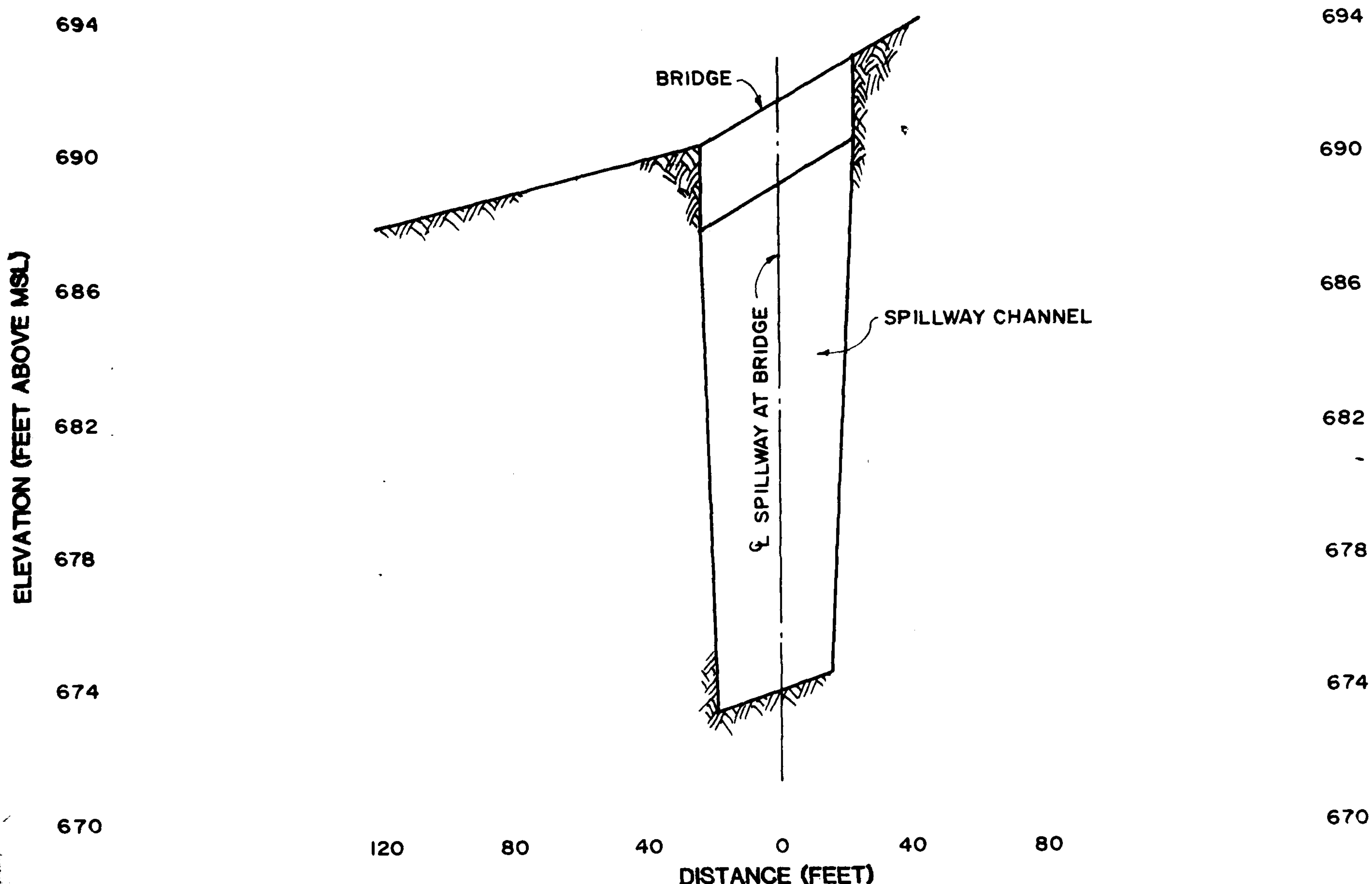
CRAWFORD MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	SPILLWAY FLOWLINE PROFILE INNSBROOK ESTATES DAM NO.1 MO31714

EXHIBIT 4



CRAWFORD, MURPHY & TILLY, Inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	CROSS SECTION OF SPILLWAY AT CREST INNSBROOK EST. DAM No.1 MO31714

EXHIBIT 5



CLAWFORD MURPHY & TILLY, Inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	CROSS SECTION OF SPILLWAY AT BRIDGE INNSBROOK EST. DAM No.1 MO31714

EXHIBIT 6

```
A1 NATIONAL DAM SAFETY PROGRAM -- CORPS OF ENGINEERS, ST. LOUIS DISTRICT
A2 HYDROLOGIC/HYDRAULIC ANALYSIS -- INNSBROOK ESTATES DAM NO. 1(MO 31714)
A3 WARREN COUNTY, MISSOURI               CM&T JOB NO. 8034-02  MARCH 24, 1981
B     240       0       6       0       0       0       0       0      -2       0
B1      5
J       1       9       1
J1   0.16    0.17    0.30    0.33    0.34    0.35    0.50    0.75     1.0
K       0  AREA 1                                       1
K1 INFLOW HYDROGRAPH COMPUTATION FOR SUBAREA 1
M       1       2    3.85                       1
P       0    25.0     102     120     130
T                                                      -1     -94             0.01
W2           0.27
X       2    -0.1     1.4
K       0  AREA 2                                       1
K1 INFLOW HYDROGRAPH COMPUTATION FOR SUBAREA 2
M       1       2    3.65                       1
P       0    25.0     102     120     130
T                                                      -1     -92             0.09
W2           0.56
X       1    -0.1     1.5
K       2   1 & 2
K1 COMBINING RUNOFF HYDROGRAPHS FROM SUBAREA 1 AND SUBAREA 2
K       1    LAKE                                       1
K1 RESERVOIR ROUTING BY MODIFIED PULS METHOD
Y                               1       1
Y1      1                                          -678.0      -1
Y4 678.0   679.33  679.98  680.91  682.28  683.40  684.93  686.38  687.72  688.97
Y4691.34
Y5      0     250     500    1000    2000    3000    4000    5000    6000    7000
Y5   8000
$A      0    13.8    46.0    87.2     138     191     251
$E    635     640     650     660     670     680     690
$$    678
$D 687.9      2.6     1.5     570
$L      0      50     390     510     570
$V 687.9    688.0   688.3   689.0   690.0
K      99
```

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

HEC-1 INPUT DATA
INNSBROOK ESTATES
DAM NO. 1 MO31714

EXHIBIT 7

HYDROGRAPH AT STAAREA 1 FOR PLAN 1, RTIO 4

1.	1.	1.	1.	2.	2.	2.	2.	2.	3.
6.	10.	15.	20.	24.	29.	34.	38.	43.	47.
50.	54.	57.	60.	63.	66.	68.	71.	73.	75.
78.	80.	81.	83.	85.	87.	88.	90.	91.	92.
94.	95.	96.	97.	98.	99.	100.	101.	102.	103.
104.	105.	106.	106.	107.	108.	109.	109.	110.	110.
130.	196.	292.	379.	441.	480.	505.	523.	536.	545.
552.	558.	562.	566.	570.	572.	575.	577.	579.	581.
583.	585.	586.	588.	589.	590.	591.	592.	593.	594.
595.	596.	597.	597.	598.	599.	599.	600.	600.	601.
601.	602.	602.	603.	603.	603.	604.	604.	604.	605.
605.	605.	605.	606.	606.	606.	606.	607.	607.	607.
677.	917.	1257.	1564.	1772.	1891.	1965.	2010.	2037.	2053.
2083.	2158.	2259.	2350.	2410.	2445.	2466.	2479.	2487.	2498.
2525.	2630.	2777.	2909.	2999.	3050.	3081.	3100.	3112.	3119.
3125.	3173.	3352.	3753.	4752.	7239.	10581.	12223.	11431.	9306.
7164.	5632.	4573.	3914.	3519.	3282.	3139.	3055.	3001.	2962.
2906.	2796.	2646.	2514.	2425.	2374.	2343.	2325.	2314.	2307.
2202.	1857.	1368.	1195.	1156.	1117.	1080.	1045.	1010.	977.
944.	913.	883.	854.	825.	798.	772.	746.	722.	698.
675.	652.	631.	610.	590.	570.	551.	533.	515.	498.
482.	466.	450.	436.	421.	407.	394.	381.	368.	356.
344.	333.	322.	311.	301.	291.	281.	272.	263.	254.
246.	238.	230.	222.	215.	208.	205.	205.	205.	205.

HYDROGRAPH AT STAAREA 2 FOR PLAN 1, RTIO 4

0.	1.	1.	2.	4.	5.	7.	8.	9.	9.
10.	11.	11.	12.	13.	14.	16.	18.	21.	24.
26.	29.	32.	35.	38.	41.	44.	46.	49.	51.
54.	56.	58.	60.	62.	64.	66.	68.	69.	71.
73.	74.	75.	77.	78.	79.	81.	82.	83.	84.
85.	86.	87.	88.	89.	90.	91.	92.	92.	93.
97.	108.	128.	162.	205.	251.	297.	339.	375.	403.
426.	444.	460.	473.	483.	493.	500.	507.	513.	518.
523.	526.	530.	533.	536.	539.	541.	543.	545.	547.
548.	550.	551.	553.	554.	555.	556.	557.	558.	559.
560.	561.	561.	562.	563.	563.	564.	565.	565.	566.
566.	567.	567.	568.	568.	568.	569.	569.	570.	570.
583.	621.	698.	825.	985.	1154.	1318.	1463.	1583.	1672.
1743.	1805.	1868.	1935.	2005.	2072.	2133.	2185.	2228.	2261.
2290.	2325.	2373.	2439.	2517.	2596.	2672.	2738.	2793.	2833.
2864.	2895.	2943.	3037.	3274.	3830.	4717.	5895.	7102.	7893.
8145.	7933.	7365.	6589.	5740.	5048.	4516.	4115.	3801.	3558.
3368.	3209.	3068.	2931.	2800.	2678.	2571.	2481.	2409.	2355.
2296.	2209.	2070.	1866.	1620.	1365.	1124.	911.	800.	768.
738.	708.	680.	653.	627.	602.	578.	555.	533.	512.
492.	472.	453.	435.	418.	402.	386.	370.	356.	341.
328.	315.	302.	290.	279.	268.	257.	247.	237.	228.
219.	210.	202.	194.	194.	194.	194.	194.	194.	194.
194.	194.	194.	194.	194.	194.	194.	194.	194.	194.

SUM OF 2 HYDROGRAPHS AT 1 & 2 PLAN 1 RTIO 4

1.	2.	3.	4.	5.	7.	8.	10.	11.	13.
16.	20.	26.	31.	37.	43.	50.	57.	63.	70.
77.	83.	89.	95.	101.	107.	112.	117.	122.	127.
131.	135.	140.	143.	147.	151.	154.	157.	160.	163.
166.	169.	172.	174.	177.	179.	181.	183.	185.	187.
189.	191.	193.	195.	196.	198.	199.	201.	202.	204.
227.	304.	420.	542.	646.	731.	803.	862.	910.	948.
977.	1002.	1022.	1039.	1053.	1065.	1075.	1084.	1092.	1099.
1106.	1111.	1116.	1121.	1125.	1129.	1132.	1135.	1138.	1141.
1143.	1146.	1148.	1150.	1152.	1153.	1155.	1157.	1158.	1160.
1161.	1162.	1163.	1165.	1166.	1167.	1168.	1169.	1169.	1170.
1171.	1172.	1173.	1173.	1174.	1175.	1175.	1176.	1176.	1177.
1260.	1538.	1956.	2390.	2757.	3046.	3283.	3472.	3620.	3726.
3826.	3963.	4127.	4285.	4415.	4517.	4599.	4664.	4715.	4753.
4816.	4955.	5150.	5349.	5515.	5646.	5753.	5838.	5904.	5952.
5989.	6067.	6295.	6790.	8026.	11069.	15298.	18118.	18533.	17199.
15309.	13565.	11938.	10503.	9260.	8330.	7655.	7170.	6802.	6520.
6274.	6005.	5714.	5445.	5225.	5053.	4914.	4806.	4722.	4662.
4498.	4065.	3438.	3061.	2775.	2482.	2204.	1956.	1810.	1745.
1682.	1622.	1563.	1507.	1453.	1401.	1350.	1302.	1255.	1210.
1166.	1125.	1084.	1045.	1008.	972.	937.	903.	871.	840.
810.	781.	753.	726.	700.	675.	651.	628.	605.	584.
563.	543.	523.	505.	495.	485.	475.	466.	457.	448.
440.	432.	424.	416.	409.	402.	399.	399.	399.	399.

STATION LAKE, PLAN 1, RATIO 4

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	1.	1.	1.	2.	2.	3.	3.	4.
4.	5.	6.	6.	7.	8.	9.	10.	11.	12.
13.	14.	15.	16.	17.	18.	19.	20.	22.	23.
24.	25.	27.	28.	29.	30.	32.	33.	34.	35.
37.	38.	39.	41.	42.	43.	45.	46.	47.	49.
50.	52.	55.	58.	63.	68.	74.	81.	87.	94.
102.	109.	117.	125.	132.	140.	148.	156.	164.	171.
179.	187.	195.	202.	210.	218.	225.	233.	240.	248.
260.	275.	290.	304.	319.	333.	346.	360.	373.	386.
399.	412.	424.	437.	449.	460.	472.	484.	495.	509.
524.	539.	553.	567.	581.	595.	608.	621.	634.	646.
659.	676.	701.	734.	776.	824.	877.	933.	992.	1070.
1151.	1234.	1318.	1404.	1492.	1580.	1668.	1756.	1842.	1926.
2012.	2114.	2218.	2325.	2434.	2544.	2654.	2763.	2871.	2976.
3058.	3133.	3210.	3294.	3396.	3549.	3786.	4107.	4467.	4802.
5092.	5339.	5533.	5682.	5791.	5869.	5923.	5962.	5988.	6006.
6017.	6020.	6016.	6004.	5986.	5964.	5939.	5911.	5882.	5851.
5818.	5778.	5726.	5661.	5590.	5512.	5429.	5341.	5250.	5158.
5067.	4978.	4894.	4811.	4728.	4646.	4564.	4483.	4402.	4322.
4242.	4164.	4086.	4008.	3935.	3864.	3792.	3722.	3652.	3583.
3515.	3447.	3380.	3315.	3249.	3185.	3122.	3059.	2996.	2913.
2832.	2753.	2676.	2601.	2528.	2456.	2387.	2320.	2254.	2191.
2129.	2069.	2011.	1962.	1917.	1873.	1830.	1788.	1747.	1707.

CM&T

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

INFLOW & OUTFLOW, 33% PMF
INNSBROOK ESTATES
DAM NO.1 MO31714

EXHIBIT 8

HYDROGRAPH AT STAAREA 1 FOR PLAN 1, RTIO 7

1.	1.	2.	2.	2.	3.	3.	3.	3.	5.
9.	15.	22.	30.	37.	44.	51.	58.	65.	71.
76.	81.	86.	91.	96.	100.	104.	107.	111.	114.
118.	121.	123.	126.	129.	131.	134.	136.	138.	140.
142.	144.	146.	147.	149.	151.	152.	154.	155.	156.
158.	159.	160.	161.	162.	163.	164.	165.	166.	167.
197.	298.	442.	575.	669.	727.	766.	793.	812.	825.
836.	845.	852.	858.	863.	867.	871.	874.	878.	881.
883.	886.	888.	890.	892.	894.	896.	897.	899.	900.
901.	903.	904.	905.	906.	907.	908.	909.	909.	910.
911.	912.	912.	913.	914.	914.	915.	915.	916.	916.
917.	917.	917.	918.	918.	919.	919.	919.	913.	920.
1026.	1389.	1905.	2370.	2685.	2866.	2977.	3045.	3086.	3111.
3157.	3270.	3423.	3560.	3652.	3704.	3736.	3756.	3768.	3776.
3826.	3985.	4208.	4408.	4543.	4621.	4668.	4697.	4715.	4725.
4735.	4807.	5079.	5687.	7200.	10968.	16033.	18520.	17320.	14100.
10855.	8533.	6928.	5931.	5332.	4973.	4757.	4628.	4547.	4488.
4403.	4236.	4010.	3809.	3674.	3598.	3551.	3522.	3506.	3495.
3337.	2813.	2073.	1811.	1751.	1693.	1637.	1583.	1531.	1480.
1431.	1384.	1338.	1294.	1251.	1209.	1169.	1131.	1093.	1057.
1022.	988.	956.	924.	893.	864.	835.	808.	781.	755.
730.	706.	683.	660.	638.	617.	597.	577.	558.	533.
521.	504.	488.	471.	456.	441.	426.	412.	398.	385.
372.	360.	348.	337.	326.	315.	310.	310.	310.	310.

HYDROGRAPH AT STAAREA 2 FOR PLAN 1, RTIO 7

1.	1.	2.	4.	6.	8.	10.	12.	13.	14.
15.	16.	17.	18.	19.	21.	24.	28.	31.	36.
40.	45.	49.	53.	58.	62.	66.	70.	74.	78.
81.	85.	88.	91.	94.	97.	100.	102.	105.	107.
110.	112.	114.	116.	118.	120.	122.	124.	126.	127.
129.	131.	132.	134.	135.	136.	138.	139.	140.	141.
147.	163.	195.	246.	311.	381.	450.	513.	568.	610.
645.	673.	696.	716.	733.	746.	758.	768.	777.	785.
792.	798.	803.	808.	812.	816.	820.	823.	826.	828.
831.	833.	835.	837.	839.	841.	842.	844.	845.	847.
848.	849.	850.	852.	853.	854.	855.	855.	856.	857.
858.	859.	859.	860.	861.	861.	862.	862.	863.	864.
883.	941.	1058.	1251.	1493.	1749.	1997.	2216.	2399.	2534.
2641.	2735.	2830.	2933.	3038.	3139.	3232.	3311.	3376.	3425.
3470.	3523.	3596.	3696.	3813.	3934.	4048.	4149.	4231.	4292.
4339.	4386.	4459.	4601.	4960.	5803.	7147.	8932.	10760.	11958.
12341.	12020.	11159.	9983.	8698.	7648.	6842.	6235.	5760.	5391.
5103.	4863.	4648.	4441.	4242.	4058.	3896.	3759.	3649.	3568.
3479.	3346.	3137.	2827.	2454.	2068.	1702.	1381.	1212.	1164.
1118.	1073.	1031.	990.	950.	913.	876.	842.	808.	776.
745.	716.	687.	660.	634.	608.	584.	561.	539.	517.
497.	477.	458.	440.	422.	406.	389.	374.	359.	345.
331.	318.	305.	294.	294.	294.	294.	294.	294.	294.
294.	294.	294.	294.	294.	294.	294.	294.	294.	294.

SUM OF 2 HYDROGRAPHS AT 1 & 2 PLAN 1 RTIO 7

2.	2.	4.	6.	8.	10.	13.	15.	17.	20.
24.	31.	39.	47.	56.	66.	76.	86.	96.	106.
116.	126.	136.	145.	153.	162.	170.	178.	185.	192.
199.	205.	211.	217.	223.	228.	233.	238.	243.	248.
252.	256.	260.	264.	267.	271.	274.	278.	281.	284.
287.	289.	292.	295.	297.	300.	302.	304.	306.	309.
345.	461.	636.	821.	980.	1108.	1216.	1306.	1379.	1436.
1481.	1518.	1548.	1574.	1595.	1614.	1629.	1643.	1655.	1666.
1675.	1683.	1691.	1698.	1704.	1710.	1715.	1720.	1725.	1729.
1732.	1736.	1739.	1742.	1745.	1748.	1750.	1753.	1755.	1757.
1759.	1761.	1763.	1764.	1766.	1768.	1769.	1771.	1772.	1773.
1774.	1776.	1777.	1778.	1779.	1780.	1781.	1782.	1783.	1783.
1910.	2330.	2963.	3621.	4178.	4615.	4974.	5261.	5484.	5645.
5798.	6005.	6253.	6492.	6690.	6844.	6968.	7067.	7145.	7201.
7297.	7508.	7804.	8104.	8357.	8555.	8717.	8846.	8946.	9018.
9074.	9193.	9538.	10288.	12160.	16771.	23179.	27452.	28080.	26053.
23195.	20553.	18088.	15913.	14030.	12621.	11598.	10864.	10307.	9879.
9506.	9099.	8658.	8250.	7916.	7656.	7446.	7281.	7155.	7064.
6816.	6160.	5210.	4638.	4205.	3761.	3339.	2964.	2743.	2644.
2549.	2457.	2368.	2283.	2201.	2122.	2046.	1972.	1901.	1833.
1767.	1704.	1643.	1584.	1527.	1472.	1419.	1369.	1320.	1272.
1227.	1183.	1141.	1100.	1061.	1023.	986.	951.	917.	884.
853.	822.	793.	766.	750.	735.	720.	706.	693.	679.
667.	654.	642.	631.	620.	609.	604.	604.	604.	604.

STATION LAKE, PLAN 1, RATIO 7

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
1.	1.	1.	2.	2.	3.	3.	4.	5.	6.
6.	7.	9.	10.	11.	12.	13.	15.	16.	18.
19.	21.	22.	24.	26.	27.	29.	31.	33.	35.
36.	38.	40.	42.	44.	46.	48.	50.	52.	54.
56.	58.	60.	62.	64.	66.	68.	70.	72.	74.
76.	79.	83.	88.	95.	103.	112.	122.	132.	143.
154.	165.	176.	188.	200.	211.	223.	235.	246.	267.
290.	313.	336.	359.	381.	404.	425.	447.	468.	489.
513.	541.	568.	595.	621.	647.	672.	697.	721.	744.
767.	790	812.	833.	854.	875.	895.	915.	934.	953.
971.	989.	1009.	1033.	1055.	1077.	1098.	1119.	1139.	1158.
1179.	1207.	1251.	1312.	1389.	1479.	1577.	1682.	1790.	1901.
2015.	2153.	2293.	2437.	2582.	2728.	2872.	3011.	3115.	3217.
3318.	3420.	3525.	3635.	3748.	3863.	3979.	4101.	4223.	4344.
4462.	4580.	4699.	4829.	4987.	5238.	5625.	6143.	7166.	8733.
10367.	11675.	12613.	13172.	13405.	13394.	13228.	12971.	12668.	12346.
12020.	11692.	11360.	11025.	10694.	10376.	10075.	9794.	9534.	9296.
9072.	8833.	8553.	8248.	7940.	7608.	7293.	7000.	6738.	6523.
6360.	6234.	6128.	6023.	5924.	5827.	5730.	5633.	5537.	5441.
5345.	5250.	5155.	5061.	4970.	4884.	4799.	4714.	4630.	4547.
4464.	4382.	4300.	4220.	4140.	4061.	3984.	3910.	3837.	3765.
3694.	3624.	3554.	3485.	3418.	3351.	3285.	3221.	3158.	3095.
3034.	2965.	2885.	2807.	2731.	2658.	2586.	2517.	2450.	2385.

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

INFLOW & OUTFLOW, 50% PMF
INNSBROOK ESTATES
DAM NO.1 MO31714

EXHIBIT 9

HYDROGRAPH AT STAARFA 1 FOR PLAN 1, RTIO 9

2.	3.	4.	4.	5.	5.	5.	6.	7.	10.
18.	30.	44.	59.	74.	89.	103.	116.	129.	141.
152.	163.	173.	182.	191.	200.	208.	215.	222.	229.
235.	241.	247.	252.	258.	262.	267.	272.	276.	280.
284.	288.	291.	295.	298.	301.	304.	307.	310.	313.
315.	318.	320.	322.	325.	327.	329.	331.	333.	335.
394.	595.	884.	1150.	1337.	1454.	1532.	1585.	1623.	1651.
1672.	1690.	1704.	1716.	1726.	1734.	1742.	1749.	1755.	1761.
1767.	1772.	1776.	1780.	1784.	1788.	1791.	1795.	1798.	1800.
1803.	1805.	1808.	1810.	1812.	1814.	1816.	1817.	1819.	1820.
1822.	1823.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.
1833.	1834.	1835.	1836.	1836.	1837.	1838.	1838.	1839.	1840.
2053.	2779.	3810.	4740.	5371.	5732.	5955.	6090.	6171.	6222.
6313.	6540.	6846.	7120.	7304.	7408.	7473.	7512.	7537.	7552.
7652.	7970.	8415.	8816.	9087.	9241.	9337.	9394.	9423.	9450.
9470.	9614.	10159.	11374.	14400.	21936.	32065.	37040.	34640.	28200.
21709.	17066.	13857.	11861.	10664.	9945.	9513.	9257.	9094.	8975.
8807.	8472.	8019.	7618.	7349.	7195.	7101.	7045.	7011.	6991.
6674.	5626.	4145.	3622.	3502.	3386.	3274.	3166.	3061.	2960.
2862.	2767.	2676.	2587.	2502.	2419.	2339.	2261.	2187.	2114.
2044.	1977.	1911.	1848.	1787.	1728.	1671.	1615.	1562.	1510.
1460.	1412.	1365.	1320.	1276.	1234.	1193.	1154.	1116.	1079.
1043.	1008.	975.	943.	912.	881.	852.	824.	797.	770.
745.	720.	696.	673.	651.	630.	621.	621.	621.	621.

HYDROGRAPH AT STAAREA 2 FOR PLAN 1, RTIO 9

1.	2.	4.	7.	11.	16.	20.	24.	27.	29.
30.	32.	33.	35.	39.	43.	48.	55.	63.	71.
80.	89.	98.	107.	116.	124.	132.	140.	148.	155.
163.	169.	176.	182.	188.	194.	200.	205.	210.	215.
220.	224.	229.	233.	237.	241.	244.	248.	252.	255.
258.	261.	264.	267.	270.	273.	275.	278.	280.	283.
295.	326.	389.	492.	622.	762.	900.	1026.	1135.	1221.
1289.	1346.	1393.	1432.	1465.	1493.	1517.	1537.	1555.	1570.
1583.	1595.	1606.	1616.	1624.	1632.	1639.	1646.	1652.	1657.
1662.	1666.	1670.	1674.	1678.	1681.	1685.	1688.	1691.	1693.
1696.	1699.	1701.	1703.	1705.	1707.	1709.	1711.	1713.	1714.
1716.	1717.	1719.	1720.	1721.	1723.	1724.	1725.	1726.	1727.
1766.	1882.	2117.	2501.	2985.	3498.	3994.	4433.	4797.	5068.
5282.	5470.	5660.	5865.	6076.	6279.	6463.	6622.	6753.	6850.
6941.	7047.	7192.	7392.	7627.	7868.	8097.	8297.	8462.	8585.
8677.	8772.	8917.	9203.	9920.	11606.	14294.	17864.	21520.	23917.
24681.	24039.	22319.	19966.	17395.	15297.	13684.	12471.	11519.	10782.
10206.	9725.	9297.	8882.	8484.	8116.	7791.	7518.	7299.	7137.
6957.	6693.	6274.	5655.	4908.	4136.	3405.	2762.	2424.	2328.
2235.	2147.	2061.	1979.	1901.	1825.	1753.	1683.	1616.	1552.
1490.	1431.	1374.	1320.	1267.	1217.	1168.	1122.	1077.	1035.
994.	954.	916.	880.	845.	811.	779.	748.	718.	690.
662.	636.	611.	588.	588.	588.	588.	588.	588.	588.
588.	588.	588.	588.	588.	588.	588.	588.	588.	588.

SUM OF 2 HYDROGRAPHS AT 1 & 2 PLAN 1 RTIO 9

3.	5.	8.	12.	16.	21.	25.	29.	33.	39.
49.	62.	78.	95.	113.	132.	151.	172.	192.	212.
232.	252.	271.	289.	307.	324.	340.	355.	370.	384.
398.	411.	423.	435.	446.	457.	467.	477.	486.	495.
504.	512.	520.	528.	535.	542.	549.	555.	561.	567.
573.	579.	584.	589.	595.	599.	604.	609.	613.	617.
689.	922.	1273.	1641.	1959.	2215.	2432.	2612.	2758.	2872.
2962.	3035.	3097.	3148.	3191.	3227.	3259.	3286.	3310.	3331.
3350.	3367.	3382.	3396.	3409.	3420.	3431.	3440.	3449.	3457.
3465.	3472.	3478.	3484.	3490.	3495.	3500.	3505.	3510.	3514.
3518.	3522.	3526.	3529.	3532.	3535.	3538.	3541.	3544.	3546.
3549.	3551.	3553.	3556.	3558.	3560.	3562.	3563.	3565.	3567.
3819.	4661.	5927.	7242.	8356.	9230.	9948.	10522.	10969.	11290.
11595.	12010.	12507.	12985.	13380.	13687.	13936.	14135.	14289.	14402.
14593.	15016.	15607.	16208.	16714.	17109.	17433.	17692.	17892.	18035.
18147.	18386.	19076.	20576.	24321.	33541.	46359.	54903.	56160.	52117.
46391.	41106.	36175.	31827.	28059.	25242.	23197.	21727.	20613.	19758.
19013.	18197.	17316.	16501.	15832.	15312.	14892.	14563.	14310.	14128.
13631.	12319.	10419.	9277.	8410.	7522.	6679.	5928.	5485.	5288.
5097.	4914.	4737.	4567.	4402.	4244.	4091.	3944.	3803.	3666.
3535.	3408.	3285.	3168.	3054.	2945.	2839.	2737.	2639.	2545.
2454.	2366.	2281.	2200.	2121.	2045.	1972.	1902.	1834.	1768.
1705.	1644.	1586.	1531.	1500.	1470.	1440.	1412.	1385.	1359.
1333.	1309.	1285.	1262.	1239.	1218.	1209.	1209.	1209.	1209.

STATION LAKE, PLAN 1, RATIO 9

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	1.	1.	1.	1.
2.	2.	3.	4.	4.	5.	7.	8.	9.	11.
13.	15.	17.	19.	22.	24.	27.	30.	32.	35.
38.	42.	45.	48.	51.	55.	58.	62.	65.	69.
73.	76.	80.	84.	88.	91.	95.	99.	103.	107.
111.	115.	119.	123.	127.	131.	135.	139.	143.	146.
151.	156.	164.	175.	189.	204.	222.	241.	273.	316.
359.	403.	447.	491.	550.	611.	671.	730.	788.	845.
902.	957.	1015.	1087.	1157.	1224.	1290.	1355.	1417.	1478.
1536.	1594.	1649.	1703.	1756.	1807.	1857.	1905.	1952.	1997.
2050.	2102.	2153.	2201.	2248.	2293.	2337.	2379.	2420.	2460.
2498.	2535.	2570.	2604.	2638.	2670.	2701.	2731.	2760.	2788.
2819.	2868.	2952.	3057.	3176.	3317.	3473.	3641.	3815.	3994.
4184.	4377.	4575.	4779.	4987.	5213.	5439.	5664.	5886.	6111.
6364.	6773.	7356.	8054.	8759.	9531.	10333.	11137.	11923.	12670.
13364.	14010.	14646.	15360.	16364.	18209.	21580.	26383.	31484.	35613.
38160.	39215.	39106.	38143.	36607.	34764.	32838.	30971.	29236.	27659.
26240.	24951.	23755.	22635.	21593.	20639.	19775.	18999.	18308.	17698.
17135.	16531.	15794.	14965.	14133.	13320.	12527.	11764.	11055.	10424.
9871.	9382.	8949.	8564.	8222.	7905.	7593.	7315.	7068.	6849.
6656.	6496.	6367.	6262.	6171.	6084.	5997.	5914.	5831.	5747.
5662.	5577.	5492.	5407.	5322.	5236.	5151.	5066.	4982.	4903.
4825.	4747.	4668.	4591.	4514.	4437.	4362.	4288.	4215.	4142.
4071.	4001.	3935.	3870.	3806.	3743.	3680.	3619.	3560.	3502.

CMT

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

INFLOW & OUTFLOW,100% PMF
INNSBROOK ESTATES
DAM NO. 1 MO31714

EXHIBIT 10

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .16	RATIO 2 .17	RATIO 3 .30	RATIO 4 .33	RATIO 5 .34	RATIO 6 .35	RATIO 7 .50	RATIO 8 .75	RATIO 9 1.00
				RATIOS APPLIED TO FLOWS								
HYDROGRAPH AT	AREA 1	3.85	1	5926.	6297.	11112.	12223.	12593.	12964.	18520.	27780.	37040.
	(	9.97)	(	167.81)(	178.30)(	314.65)(	346.12)(	356.61)(	367.10)(	524.42)(	786.63)(	1048.84)
HYDROGRAPH AT	AREA 2	3.65	1	3949.	4196.	7404.	8145.	8392.	8638.	12341.	18511.	24681.
	(	9.45)	(	111.82)(	118.81)(	209.67)(	230.64)(	237.63)(	244.62)(	349.45)(	524.18)(	698.90)
2 COMBINED	1 & 2	7.50	1	8986.	9547.	16848.	18533.	19094.	19656.	28080.	42120.	56160.
	(	19.42)	(	254.44)(	270.35)(	477.08)(	524.79)(	540.69)(	556.59)(	795.13)(	1192.70)(	1590.27)
ROUTED TO	LAKE	7.50	1	3021.	3196.	5482.	6020.	6210.	6438.	13405.	27219.	39215.
	(	19.42)	(	85.55)(	90.49)(	155.23)(	170.47)(	175.84)(	182.30)(	379.58)(	770.75)(	1110.45)

1

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	678.00	678.00	687.90
STORAGE	3345.	3345.	5406.
OUTFLOW	0.	0.	6144.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.16	683.43	0.00	4405.	3021.	0.00	17.10	0.00
.17	683.70	0.00	4461.	3196.	0.00	17.10	0.00
.30	687.03	0.00	5200.	5482.	0.00	17.20	0.00
.33	687.75	0.00	5369.	6020.	0.00	17.20	0.00
.34	687.98	.08	5425.	6210.	.90	17.20	0.00
.35	688.21	.31	5479.	6438.	1.60	17.20	0.00
.50	690.55	2.65	6059.	13405.	3.40	16.50	0.00
.75	693.16	5.26	6744.	27219.	5.10	16.30	0.00
1.00	694.95	7.05	7241.	39215.	6.50	16.20	0.00

CRAWFORD MURPHY & TILLY inc Consulting Engineers
SPRINGFIELD, IL • LINCOLN IL • AURORA, IL

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
NATIONAL DAM SAFETY PROGRAM

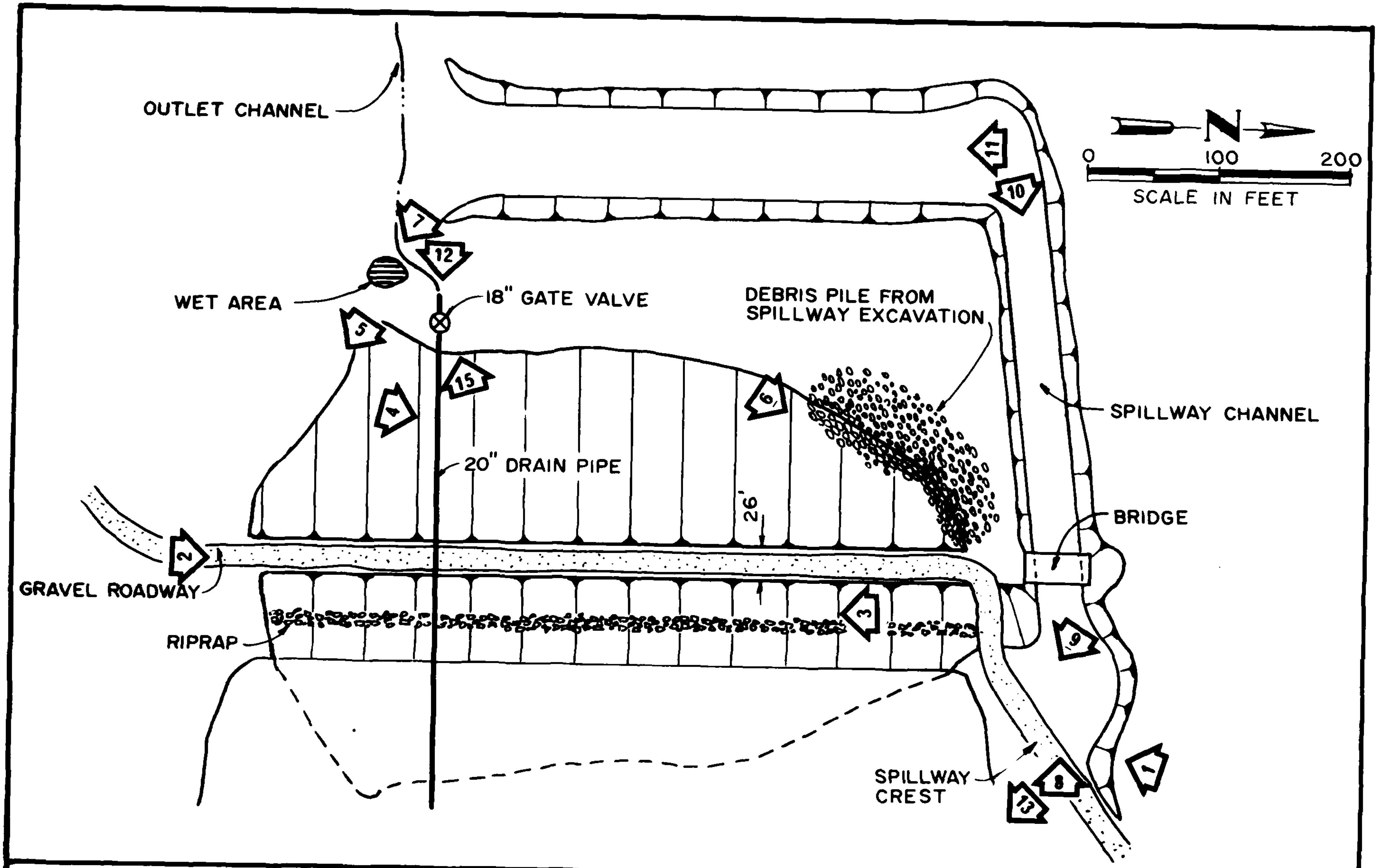
HEC-1 SUMMARY TABLE
INNSBROOK ESTATES DAM No.1 MO31714

EXHIBIT 11

PHASE I INSPECTION REPORT

APPENDIX C

PHOTOGRAPHS

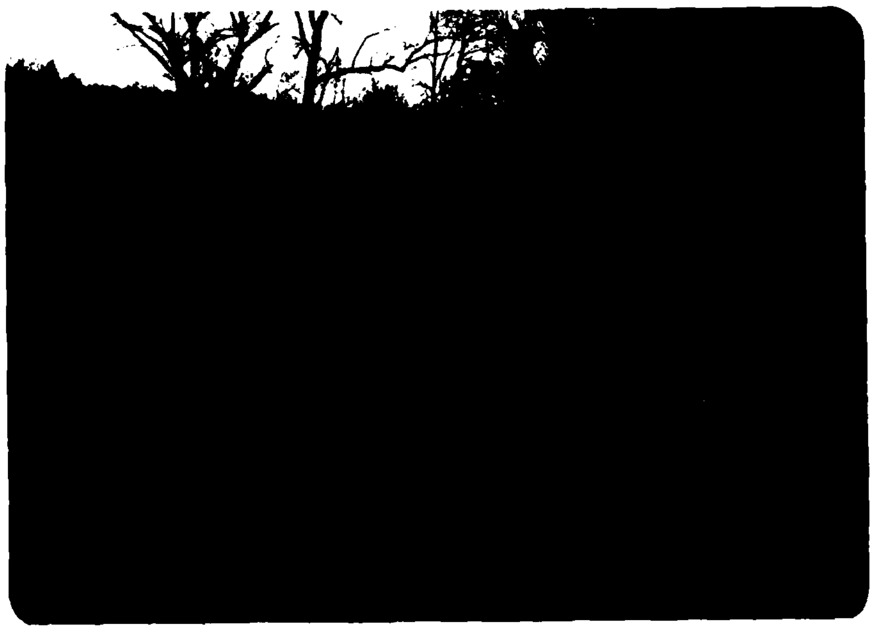


CRAWFORD, MURPHY & TILLY, inc. Consulting Engineers SPRINGFIELD, IL • LINCOLN, IL • AURORA, IL	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS NATIONAL DAM SAFETY PROGRAM	PHOTOGRAPH INDEX INNSBROOK ESTATES DAM NO.1 MO31714

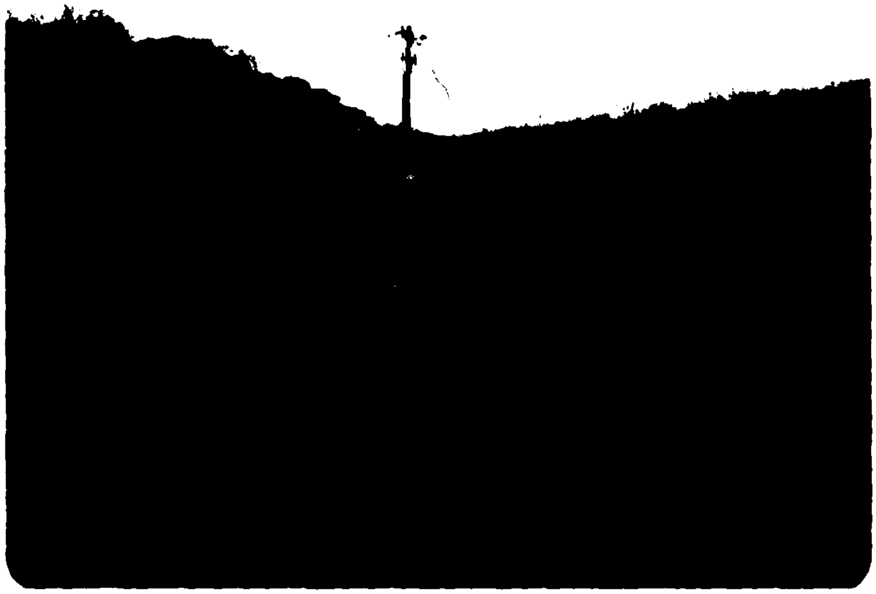
Photograph 2. Crest of dam viewed from left abutment.

Photograph 3. Upstream slope of dam viewed from right half of embankment.

Photograph 4. Downstream slope of dam viewed from center of dam looking towards right abutment.



Photograph 5. View of left abutment on downstream slope. Note erosion of embankments from surface drainage.



Photograph 6. View of right abutment on downstream slope. Note rock debris from excavation of spillway.

Photograph 7. View of seepage along downstream toe of dam near left abutment.

Photograph 8. Spillway channel looking downstream from right side of spillway crest.

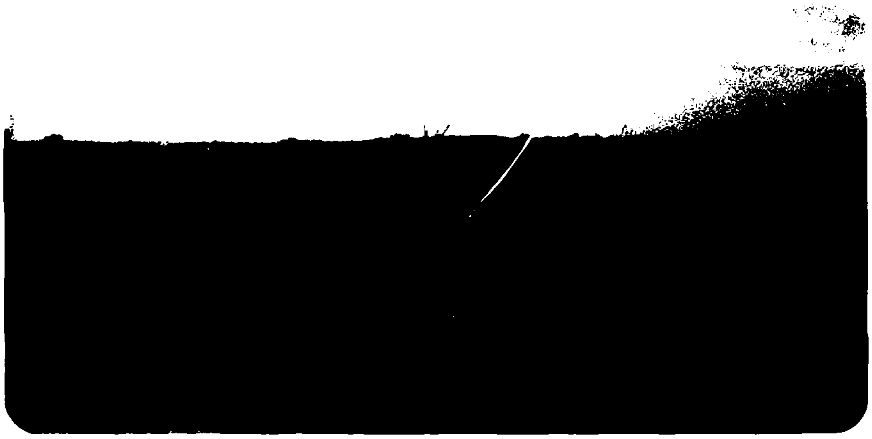
Photograph 9. View of spillway crest looking upstream from spillway channel.

Photograph 10. View of spillway outlet channel looking upstream.

Photograph 11. Spillway outlet channel looking downstream. Toe of dam is along left edge of photograph.

Photograph 12. Downstream outlet of drawdown conduit. Gate valve enclosure is in top center of picture.

Photograph 13. Looking from the crest of the spillway across Innsbrook Lake.



Photograph 14. Typical view of watershed area showing mixture of open fields and wooded areas.

Photograph 15. View of downstream channel from toe of dam. Enclosure for gate valve on drawdown conduit is in the foreground.

DATE
ILMED
-8